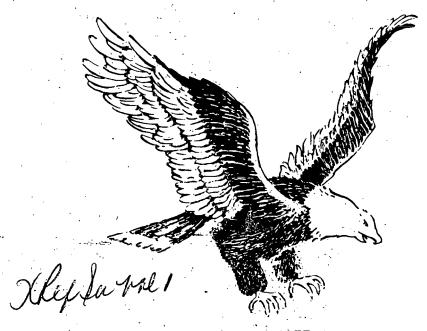
INSTALLATION ASSESSMENT OF

PINE BLUFF ARSENAL PINE BLUFF, ARKANSAS

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RECORDS EVALUATION REPORT NO. 113



AUGUST 1977

DEPARTMENT OF THE ARMY
OFFICE OF THE PROJECT MANAGER
FOR

CHEMICAL DEMILITARIZATION AND INSTALLATION RESTORATION ABERDEEN PROVING GROUND, MARYLAND 21010

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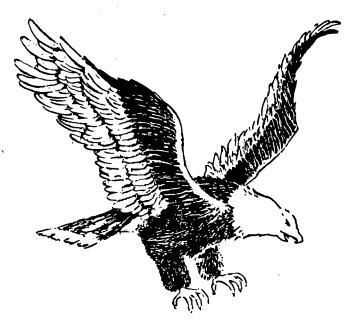
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STATEMENT

"The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation."

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INSTALLATION ASSESSMENT

OF

PINE BLUFF ARSENAL

RECORDS EVALUATION REPORT NO. 113

PREPARED BY

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FOREWORD

This Installation Assessment Report was prepared in August 1977 to document potential and actual contamination problems at Pine Bluff Arsenal so that these problems could be addressed in the Army's Installation Restoration program. A brief discussion of the positive steps which have been implemented to further identify and eliminate problem areas is contained in Appendix U.

EXECUTIVE SUMMARY

I. ŒNERAL

- A. During May 1977, a records search was conducted on Pine Bluff Arsenal (PBA) to confirm previously known areas of contamination and to determine if other undocumented contaminated areas exist.
- B. The on-site phase of the search was performed from 23 through 27 May 1977; however, data were collected from other agency sources beginning 18 April through 5 August 1977. In addition to the on-site search, Team members also contacted personnel at Aberdeen Proving Ground who were familiar with past operations at Pine Bluff Arsenal.
 - C. The procedure followed by the Records Research Team included:
- 1. Acquiring all pertinent documents on PBA from other government agencies including:
 - Department of Defense Explosive Safety Board (DDESB).
 - US Army Environmental Hygiene Agency (AEHA).
 - c. US Geological Survey (USGS).
 - d. Defense Documentation Center (DDC).
 - e. US Army Engineer Waterways Experiment Station (WES).
 - f. National Technical Information Service (NTIS).
- 2. Obtaining copies of all on-site installation regulations, standing operating procedures, and other available documentation.
 - 3. Interrogating former and present key employees.
 - 4. Analysis of above pertinent data.
- D. This report reflects the status of Pine Bluff Arsenal as of 5 August 1977.*

^{*}Appendix T contains information received from PBA on 23 December 1977 which up dated the mission, organization chart, and manpower distribution at the Arsenal. It also includes information on installation activities addressing environmental pollution and contamination control.

II. FINDINGS

- A. Pine Bluff Arsenal is contaminated with hazardous wastes resulting from various operations conducted at the Arsenal from 1942 to the present both by government agencies and by industrial concerns that leased portions of the facility. Potential contaminants identified from the search of records are DDT, arsenic, white phosphorus, barium, zinc, mustard, BZ, riot control agents, pyrotechnic materials, and industrial wastes with their associated waste products.
- B. Sterilized biological waste was disced into the soil in a field on the property deeded to the National Center for Toxicological Research (NCTR). The buildings presently used by NCTR were formerly the facilities of the Directorate of Biological Operations (DBO) at PBA.
- C. Many test areas at PBA may contain unexploded ordnance (UXO). The UXO potentially consists of high explosive rounds, mustard rounds, pyrotechnic munitions (WP, HC, smoke, colored signals), and riot control devices (CS and CN).
- D. Radiological materials were not developed, manufactured, stored, tested, or disposed of at the installation.
- E. Lethal chemical agents (mustard and lewisite) were manufactured at PBA and mustard agent is presently stored at the Toxic Storage Yard (TSY). Other items in storage at the TSY include War Gas Identification Sets, riot control agents, decontaminants and FS. GB and VX are stored in igloos in the ammunition storage area. BZ is stored in three igloos in the ammunition storage area.
- F. Groundwater and the subsurface soil is contaminated in many areas of the installation. Thirty-two sites within the boundary were evaluated by sampling and analyzing for DDT, sodium, barium, arsenic, mercury, lead, zinc, mustard, lewisite, CS, CN, DM, dyes, hexachloroethane, and white phosphorus. Twenty-nine of the sites had at least two or more contaminants at concentrations in excess of critical threshold values established by a team of scientists at the Chemical Systems Laboratory.

III. CONCLUSION

Current known areas of contamination were substantiated and additional suspected areas were located and documented.

IV. RECOMMENDATION

The preliminary surveys presently being conducted at PBA should continue because there is a strong potential for contaminant migration.

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н	List of Buildings, Pine Bluff Arsenal
I	Analysis of Existing Facilities/Environmental Assessment Report, Pine Bluff Arsenal, revised 1 December 1976
J	AEHA Waste Treatability Study No. 24-044-73/76, dated 13 February - 21 March 1974
К	AEHA Water Quality Engineering Survey No. 24-002-73, dated 17 - 21 July 1972
L	AEHA Installation Restoration Program Report No. 99-065-75/76, dated 28 - 31 July 1975
M	Preliminary Environmental Survey, No. EB-SP-74025, PBA, dated December 1976
N	PBA Regulation No. 420-5, Solid Waste Disposal, dated 5 November 1976
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Q	AEHA Water Quality Geohydrologic Consultation No. 24-004-74, dated 16 - 20 July 1973
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Ų	Installation Restoration Accomplishments As Of Oct 79

I. GENERAL

4

A. Purpose of the Assessment

- 1. To confirm previously known areas of contamination and to determine from a search of available records if other undocumented contaminated areas exist at Pine Bluff Arsenal (PBA). This information, as applicable, will be incorporated into the ongoing PBA survey.
 - 2. To identify any immediate on-post safety problems.

B. Authority

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Department of the Army (DA) Charter for the Project Manager for Chemical Demilitarization and Installation Restoration (PM CDIR) dated 29 April 1977.

C. Introduction

- 1. In response to a request from the Office of the Project Manager for Chemical Demilitarization and Installation Restoration, the Records Research Team initiated a search of PBA records.
- 2. Personnel from PBA were briefed on the program prior to the start of the on-site records search. This briefing outlined the scope of the assessment and provided guidelines to installation personnel. Mr. Glen Murtha was designated the point of contact for the Team.
- 3. Prior to the review of on-site records, various Government agencies were contacted during the period of 18 April through 20 May 1977 for documents pertinent to the records research effort. These agencies were:
 - a. Department of Defense Explosive Safety Board (DDESB).
 - b. US Army Environmental Hygiene Agency (AEHA).
 - c. US Geological Survey (USGS).
 - d. Defense Documentation Center (DDC).
 - e. US Army Engineer Waterways Experiment Station (WES).
 - f. National Technical Information Service (NTIS).
- 4. The following personnel were assigned to the Team and provided input to this report:

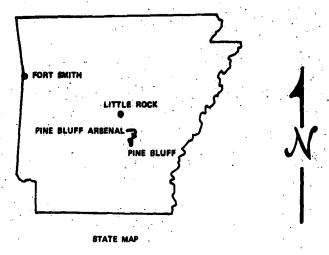
- a. Mr. William Collins (Team Leader/Chemical Engineer).
- b. Mr. Norman Leibel (Ordnance Specialist).
- c. Mr. Harry Woods (Hydrogeologist).
- d. Mr. John Bane (Chemist).
- e. Mr. Reed Magness (Chemist).
- f. LT Charles Brenner (Chemical Engineer).
- g. Mr. James Scott (PM CDIR Representative/Chemist).
- 5. In addition to the review of records, interviews were conducted with more than 25 persons, including present and former employees (see Appendix A). A ground tour of the installation was also made. Photographs taken during the tour are included in Appendix B. Team members also contacted and interviewed personnel at Aberdeen Proving Ground who either were former employees at PBA or were knowledgeable of certain operations conducted there.
- 6. The findings, conclusion, and recommendations are based on the records made available to the Team at the time of the search, and the Team cannot vouch for the accuracy of the records. Where conspicuous discrepancies existed within the data, attempts were made to determine the correct information by interviewing the personnel (if available) involved in preparing the original data.

D. Summary Description of Installation

Location and Size

PBA is located in the central portion of Jefferson County, Arkansas. It lies approximately eight miles northeast of Pine Bluff and 30 miles southeast of Little Rock. PBA lies on the west side of the Arkansas River and is 120 miles upstream from its junction with the Mississippi River. The Arsenal is approximately 400 miles from the Gulf of Mexico and over 800 miles from the Atlantic Ocean.

PBA presently contains 14,454 acres of land including 67 acres of perpetual easements acquired for railroad and natural gas distribution line right of ways between the Arsenal and the city of Pine Bluff, and 100 acres leased to the city of Pine Bluff for construction of a secondary sewage treatment facility (oxidation pond) for domestic sewage. In addition, this review includes approximately 500 acres known as the old Biological Plant now deeded to and under the control of the Food and Drug Administration and operated as the National Center for Toxicological Research (NCTR) (see Figure I-1).



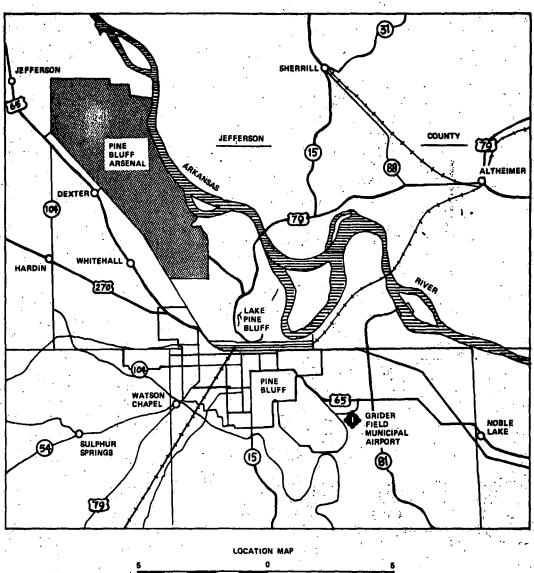


FIGURE 1-1. SITE MAP FOR PINE BLUFF ARSENAL, PINE BLUFF, ARKANSAS

SCALE OF MILES

2. Area Description

Jefferson County was founded in 1829 and is located in the central portion of the state. It is the second most populated county in the state with a population of approximately 90,000. The Arkansas River flows diagonally through the county in a southeasterly manner and borders both Pine Bluff and PBA. Pine Bluff is the county seat of Jefferson County, with a population of over 58,000 residents. Little Rock, the capital of Arkansas, is located 30 miles northwest of the Arsenal and has a population of over 135,000. Approximately 3,000 residents live within a one mile radius of the installation. This figure includes over 1,900 residents in the town of Whitehall adjoining the south-eastern boundary of the Arsenal.

The nearest counties are: Pulaski to the north with a population of over 287,000; Grant to the west with a population of over 9,700; Arkansas to the east with a population of over 23,300; and Cleveland and Lincoln to the south with populations of over 6,600 and 12,900 respectively.

PBA is bordered on the north by privately owned timber and farmland while the southern boundary is adjacent to industrial properties of which the Weyerhauser Company is the largest owner. The western boundary is adjacent to the Missouri Pacific Railway and the eastern boundary is contiguous to the Arkansas River. The land on the southern half of the Arsenal is flat while the northern half is slightly rolling. PBA is served by US Highway 65 on the west which connects Pine Bluff with Little Rock, and State Highway 79 which serves the Arsenal from the southeast by means of a two mile county road. Several major airlines serve the general area from Adams Field in Little Rock.

The land on the eastern side of the Arkansas River is relatively flat, well adapted to farming and growing hardwood timber. Numerous drainage canals and reservoirs have been built to provide water for irrigation, recreation, and fish farming. The terrain to the west of the river is flat to rolling and is predominately adapted to growing timber. There are numerous industrial plants in the area, all of which are on the west side of the Arkansas River. Industry is expected to increase in the area since the Arkansas River is now navigable from Tulsa, Oklahoma, to the Mississippi River, due to the recently completed Arkansas River Development Program.

The climate in the PBA area is considered to be mild with a mean annual temperature of 62.2°F. The average growing season is 244 days with the last killing frost expected on or about 25 March and the first killing frost expected on or about 14 November. The average rainfall for the Arsenal area is about 50 inches per year.

3. Organization and Mission

a. The mission of PBA is:

- (1) The production, manufacture, receipt, storage, shipment, surveillance, testing, maintenance, and demilitarization of chemical munitions to include chemicals, smokes, riot control, incapacitating, incendiary, and pyrotechnic mixes, for military application and to supplement commercial industrial capacity.
- (2) The support of research, development, and engineering requirements of other US Army Materiel Development and Readiness Command (DARCOM) programs.
- (3) The development of plans for supporting mobilization requirements and schedules prepared by DARCOM relevant to the Industrial Readiness Assurance Program for US Army Armament Materiel Readiness Command (ARRCOM) items.
- (4) The procurement of raw materials for accomplishment of mission responsibilities.
- (5) The administrative and logistical support for attached and/or tenant activities.
- +(6) The maintenance of facilities and equipment in a readiness condition.
- b. PBA is a Class II DARCOM installation assigned to the command jurisdiction of the commander, ARRCOM. The Arsenal's personnel strength is currently 972 employees (13 officers, 47 enlisted men, and 912 civilians). See Organization Chart, Figure I-2, and Manpower Distribution Chart. Figure I-3. for details.

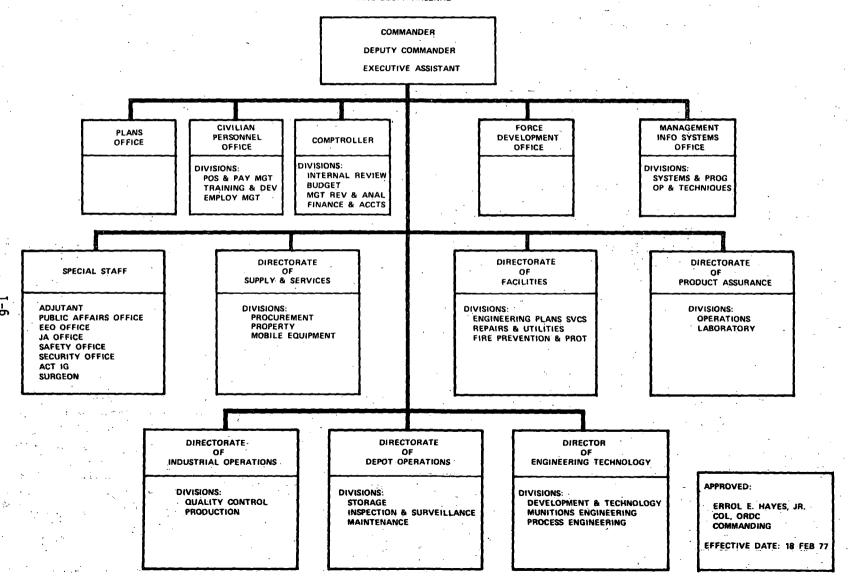
The number of personnel at PBA has fluctuated over the years, from a high of over 9,000 civilian and 450 military to a low of 700 civilians and 125 military during the period between World War II and the Korean Conflict. The Vietnam Conflict increased personnel strength to a high of 140 military and 1,850 civilians in June 1968. Strength has gradually decreased from that date to the present strength of 972 total (60 military and 912 civilians). See Appendix T).

4. History

The Arsenal was established by the War Department on 10 November 1941 and originally designated the Chemical Warfare Arsenal, Pine Bluff, Arkansas. Headquarters was established in the National Building in Pine Bluff, Arkansas. Construction of the Arsenal began on 2 December 1941. Construction included facilities for manufacture, loading, and assembly of incendiary and chemical munitions, storage magazines, laboratories, and other associated administrative and logistical support facilities. The initial cost of the installation was approximately 60 million dollars including \$250,000 for the land.

FIGURE 1-2. ORGANIZATIONAL CHART

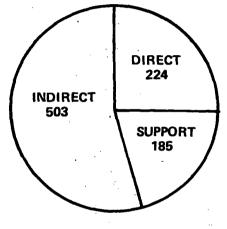
UNITED STATES ARMY ARMAMENT MATERIEL READINESS COMMAND
PINE BLUFF ARSENAL

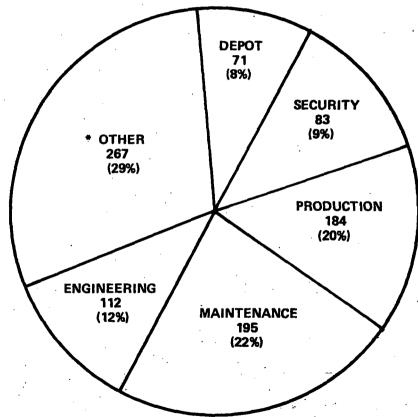


PBA MANPOWER DISTRIBUTION TDA AUTHORIZED STRENGTH, 912 1 OCTOBER 1976

* OTHER

PERSONNEL OFFICE COMPTROLLER PROCUREMENT DATA PROCESSING UTILITIES FIRE PREVENTION MOBILE EQUIPMENT RAIL TRAFFIC





EMPLOTE				
CIV	912			
OFF	13			
EM	47			
	972			

FIGURE 1-3. A POWER DISTRIBUTIO CHART

H

The Arsenal was redesignated as Pine Bluff Arsenal on 5 March 1942. The headquarters was moved from the city of Pine Bluff to Pine Bluff Arsenal on 1 April 1942.

Initial production at PBA began on 31 July 1942 with the production of the AN M14 incendiary grenade. The operations expanded rapidly through World War II years to include 24 different end items. The work performed included the production of bulk chemical agents and the filling of various chemical bombs (incendiary, smoke and other chemical munitions). Activities at the Arsenal during 1945 and the early 1950's were principally maintenance and renovation of chemical supplies and equipment, industrial mobilization planning, and demilitarization.

The Korean Conflict created an expansion of operations at PBA. A total of 38 different end items were produced during the Conflict including various grenades, smoke pots, canisters, white phosphorous, and FS shells.

In 1953 the facilities for biological warfare operations were completed at PBA and designated as the Production Development Laboratories. In 1957 the laboratories were made an integral part of the Arsenal and established as a mission element under the designation Directorate of Biological Operations (DBO).

During the 1950's excess facilities were leased in Area 5, Sections 3 and 4 to Diamond Alkali and Niagara Chemical Companies. The Diamond Alkali produced chlorine for use by Niagara which produced DDT and chlorobenzene in large quantities. Malathion and parathion were received at the Niagara site and blended into formulations.

Facilities for the production of CS munitions were added at PBA in 1961 and in 1962 the BZ munitions facility was completed. Additional facilities were added to the Biological Operations area in 1964 at a cost of over \$25,000,000.

The Presidential Executive Order of 25 November 1969 announced the discontinuance of the US biological warfare (BW) effort and the production of BW munitions. The President also directed that all existing stocks of biological components and munitions be demilitarized and destroyed. The demilitarization of all inventories of antipersonnel biological agents and munitions was completed at Pine Bluff Arsenal in January 1972. These facilities were then declared excess and the real property was transferred to the Food and Drug Administration (FDA) on 1 May 1972. FDA presently operates them as the National Center for Toxicological Research (NCTR).

E. Environmental

1. Water Quality

a. <u>Surface Water</u>. PBA is located in the Arkansas River Basin. All of the surface drainage and wastewaters generally flow in a southeasterly direction into the Arkansas River (see Figure I-4). There are six major creeks and several small ones on the Arsenal. They are Eastwood Bayou, Triplett Creek, Tulley Creek, Hospital Creek, White Creek*, Production Area Creek, Warbritton Creek, and Caney Bayou.

Eastwood Bayou drains the northern area of the post including the old biological agent storage area and the NCTR. It empties directly into the Arkansas River. Triplett Creek (also called Phillips Creek) drains the largest area on post. It drains the Toxic Storage Yard, the chemical manufacturing area, and part of the storage depot before emptying into the Arkansas River. Tulley Creek and Tulley Lake drain part of the old chemical manufacturing area, the old chlorine plant site, and most of the storage depot. Normally, Tulley Creek empties into Yellow Lake, but during flooding it empties directly into the Arkansas River. Hospital Creek empties into Yellow Lake after draining the barrack, administration, and hospital area. White Creek drains the shop and white phosphorus production areas before emptying into Yellow Lake. Production Area Creek and Warbritton Creek drain the production area and bomb storage area. They both empty into the Arkansas River through the old river bed. Caney Bayou parallels the western boundary of PBA. Areas along this boundary and southern end of the Arsenal are drained by it and eventually empties into the Arkansas River after flowing through several small towns and Lake Pine Bluff. See Table I-1 below.

TABLE I-1. SIZE OF THE VARIOUS DRAINAGE SYSTEMS LOCATED ON PINE BLUFF ARSENAL

<u>Drainage Area</u>	Number of Acres
Eastwood Bayou	2,486
Triplett Creek	3,562
Tulley Creek	2,193
Hospital Creek	1,055
White Creek	760
Production Area Creek	1,030
Caney Bayou	1,757
Arkansas River	673
Old River Bottom	631
Yellow Lake	411
Warbritton Creek	518
Ponds	379

^{*}Various references relate to the creeks name as: White Creek and White Phosphorus Creek.

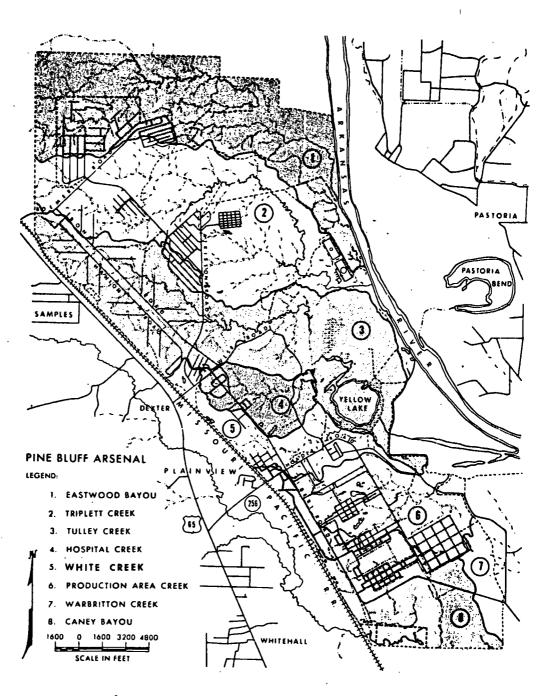


FIGURE 1-4. DRAINAGE AREAS OF US ARMY PINE BLUFF ARSENAL,
PINE BLUFF, ARKANSAS

Yellow Lake is located in the southeastern part of the post. Yellow Lake was formed as the result of an old meander of the Arkansas River being cut off during flooding sometime after 1936. Presently Yellow Lake is about 200 acres surrounded by trees and swampland. It receives backwaters from the Arkansas River during its high water stages. A list of the other small ponds and their acreage is included in Table I-2.

TABLE I-2. LIST OF SMALL PONDS

Name	Surface <u>Acreage</u>	
Yellow Lake	200	
Tulley Lake	35	
Duck Reservoir (2)	10 each, 20 acre	s total
Clear Pond	2	
Dilly Pond	3	
Gibson Pond	3 2 2	•
Big Transportation Pond	2	
Big Area 3 Pond	4	
Grassy Pond	3 2	
Arkla Pond	2	
Bomb Storage Pond	1	
Little Transportation Pond	1	
Horseshoe Pond	1 ·	
Dexter Pond	1	
Bunker Pond	1	
King Pond	1	
Thompson Pond	1	

Twelve deep wells supply all water used at PBA. There are three separate distribution systems known as the Chemical Area system, the South (IBF) Area system, and the NCTR Area system. The Chemical Area system is an industrial water distribution system with no treatment. The other two are potable systems incorporating water treatment plants. The two treatment plants are shown in Figure I-5.

Water is supplied to the NCTR Area system from Well Numbers 14, 15, 16, 17, and 18. Location of these wells is shown in Figure I-5. Three types of water are produced by this treatment plant. After general treatment, the water is pumped to an industrial water (general distribution) storage tank. This water is used for firefighting and other industrial purposes. Water from the storage tank is chlorinated before being pumped to potable distribution systems for consumption. Water from the storage tank is also diverted through one of two demineralization processes prior to its distribution to the NCTR restricted area for research applications. The average production was 51,000 gallons per day from January to July 1972.

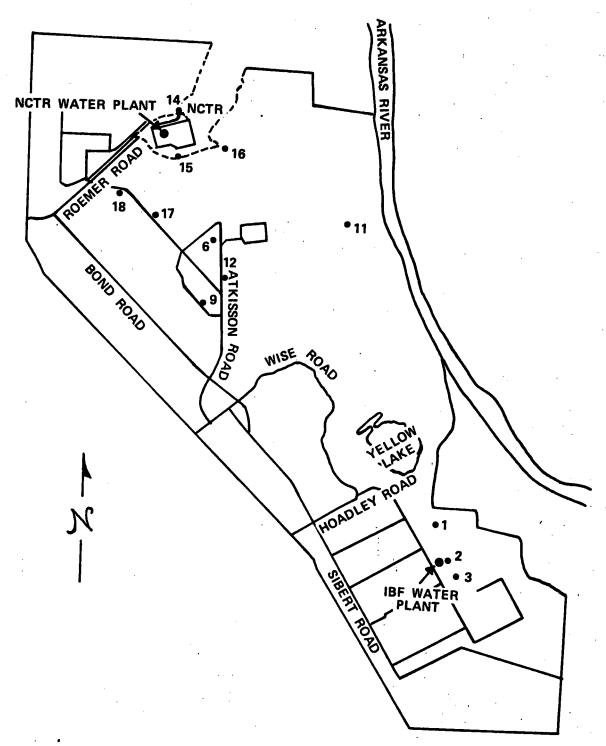


FIGURE 1-5. LOCATION OF DEEP WATER WELLS AND WATER TREATMENT.

The IBF water treatment system draws water from Wells 1, 2, and 3. Production averaged 75,000 gallons per day for the same six-month period in 1972. This system produces potable water for the post's administrative and production facilities after being subjected to the following processes: aeration over a coke tray, lime/alum chemical feed, sedimentation, anthrafilt pressure filtration, and chlorination.

The Chemical Area system supplied non-potable water for industrial purposes to the old Arkansas Louisiana Chemical Corporation (ARKLA Plant); it still serves the TSY and provides fire protection water for the Area 5 storage area. Water obtained from Wells 6, 9, 11 and 12 is pumped directly into the system without treatment and stored in three elevated 200,000 gallon steel tanks. Potable water is provided in the Chemical Area by a line from the IBF water treatment system. See Appendix C.

b. Subsurface Water. There are two significant aguifers in the PBA area: a shallow water table aquifer; and a confined aquifer tapped for water supply for PBA, industry, and the city of Pine Bluff. The shallow water table aquifer is formed by quaternary surface deposits. The water table is at 190 to 195 feet mean sea level (msl) elevation with an average depth to water of 45 feet. The flow of water in the water table aquifer is controlled by the permeability of the formation, elevation and stage of the Arkansas River, and location and amount of local recharge. Direction of flow is generally eastward to the Arkansas River at an estimated mean velocity of about 25 feet per year. This estimate could vary from slightly less to twice as much as the estimated value. There is some indication of a groundwater "ridge" in the southern portion of the manufacturing area. The high runs northeast to southwest. Groundwater flow off the southern flank of the high would be to the southeast towards an off-post area occupied by private owners. The recharge mode has not been identified. It would be from either wide-area infiltration through the soil or from stream channel influent seepage. Probably the bulk of the recharge is along stream channels with smaller amounts from surface infiltration. The water table aquifer is in hydraulic connection with the Arkansas River and ordinarily is effluent to it. During flooding there may be seepage from the river to the aquifer, but the river water would not penetrate more than 20 to 30 feet into the aquifer. A groundwater monitoring program was initiated in 1967. Table I-3 contains a description of the wells and the water levels in 1973 and 1976. Chemical analysis of the water is contained in Table I-4. The boring logs for these wells are presented in Appendix D. Logs for the deep water wells were also obtained and are included in Appendix D (see Figure I-6).

The confined aquifer known as the Sparta Sand is tapped by Arsenal wells at a depth of 800 to 1,000 feet. In the PBA area the Sparta Sand is not believed to be in hydraulic connection with surface water or shallow groundwater.

TABLE I-3. WATER LEVEL READINGS IN MONITORING WELLS

Well Num New	nbers 01 d	Location	Depth Below Gr Water Surface 1972	round to (Feet) 1976
14-02-00	5	McCoy Road	48	42
14-02-01	6	North of Hoadley Road	51.5	47
31-02-00	13	Avenue 311A at 317th St.	38.8	32
31-02-01	14	Avenue 314B at 314th St.	40	34
31-02-02	15	Avenue 311B at 310th St.	38.5	32
32-02-00	11	Avenue 321A at 328th St.	41.7	35
32-02-01	12	328th St. near Bldg 32-690	41.7	36
33-02-00	9	338th St. near Avenue 331A	43.2	36
33-02-01	10	332B Avenue near Bldg 33-670	43.2	35
33-02-02+	16	Sibert Road	46.8	40
34-02-00	7	Off Stokes Road near Avenue 34	B 46	40
42-02-00	8	On Stokes Road	43	36
54-02-00*	3	Between Bldg 53-110 and 53-220	185.5	183
56-02-00	4	Webster Road	50	42
74-02-00+	17	Near McCoy Road	50.5	42

⁺Existing wells rehabilitated.

NOTE: Wells 1 and 2 were drilled to 135 and 100 feet respectively without evidence of water. They were abandoned as dry holes.

^{*}Drilled to 685 feet to reach water. This was done by PBA in an attempt to prove the absence of useful groundwater for monitoring in the old ARKLA area.

TABLE I-4. VALUES FOR GROUNDWATER MONITORING SYSTEM JANUARY 1971 TO MARCH 1972

Constituents - mg/l

11-19 No.		•					-						
Hell No New No.	01d 110.		рН	Suspended Residue	Total Residue	Filterable Residue	Chloride	Sulfate	Nitrate	Zinc	Total Phosphate	Filtered Phosphate	<u> </u>
14-02-00	5 .	Range Ave.	6.2-7.0	0-12 4	15-314 190	14-306 186	9-98 70	3-239 52	0-14 3	.8-1.1 .57	001 0	0-0 0	16 -6 4 26
14-02-01	6	Range Ave.	6.5-7.2 6.9.	0-4	58-274 188	54-272 174	7-69 46	2-300 51	0-13 2	.03-2.0 .59	001	0-0 0	9-352 71
31-02-00	13	Range Ave.	5.9-6.8 6.2	0-9 4	57-406 131	57-404 127	3 -166 39	4-140 36	0-14 3	.5497 .72	0-0	0-0 0	4-116 35
31-02-01	14	Range Ave.	5.7-6.7 6.0	0-12 3	18-70 45	18-68 42	2-12	3-53 14	0-24 5	.61-1.1 .89	0-0 0	0-0 0	0-104 30
31-02-02	15	Range Ave.	5.6-7.0 6.0	1-6 3	2-96 55	0-92 52	2-12 7	3-111 24	0-15 6	.66-1.3 .97	0-0	0-0 0	0-72 29
32-02-00	11	Range Ave.	5.7-6.7 6.0	0-9 4	82-256 165	76-250 161	5-9 4 60	0-49 10	0-6 2	.33-1.2 .96	0-0 0	0-0 0	9-84 38
32-02-01	12	Range Ave.	5.9-6.8 6.3	2-16 7	32-106 67	26-100 59	2-15 9	3-82 18	0-7 2	.43-1.2 .92	0-0 0	0-0 0	9-90 53
33-02-00	9.	Range Ave.	5.7-6.8 6.0	2-8 4	48-158 108	46-154 103	4-65 35	3-95 16	0-3 1	.47-2.0 1.3	0-0 -0	0-0 0	4-104 36
33-02-01	10	Range Ave.	5.8-6.9 6.2	8-14 9	42-142 99	34-134 89	4-40 25	1-78 16	0-6 2	.33-1.8 1.1	0 -0 0	0-0 0	0-152 41
33-02-02	16	Range Ave.	6.4-6.8 6.5	2-12 4	100-212 155	98-210 151	5-54 34	4-41 12	0-17 4	.5082 .65	001 .01	091 0	∂-104 - 28
34-02-00	7.	Range . Ave .	6.3-7.4 6.6	0-13 5	60-144 103	56~140 97	2-22 14	2-70 17	0-11 2	.25-1.2 .92	001	0-0	9-116 42
42-02-00	. 8 .	Range Ave.	6.1-7.0 6.4	2-17 6	53-246 114	36-242 107	3-66 23	0-62 16	0-3 1	.35-3.2 1.7	0-0 0	0-0 0	0-64 23
54-02-00	3	Range Ave.	6.2-7.0 6.5	2-14 6	34-456 125	30-454 119	1-11 6	4-25 13	0-7 1	.15-1.2 .75	0-0 0	0-0	0-28 18
56-02-00	4	Range Ave.	6.1-6.4 6.2	2-18 7	142-798 442	136-792 434	17-173 97	2-335 157	0-13 4	.20-2.9 1.1	001 0	0-0 0	9-38 24
74-02-00	17	Range Ave.	6.0-6.8 6.2	1-10 · 4	29-690 326	28-686 322	12-166 99	3-658 173	0-24 6	.12-1.3 .59	0-0 0	0-0 0	4-37 27

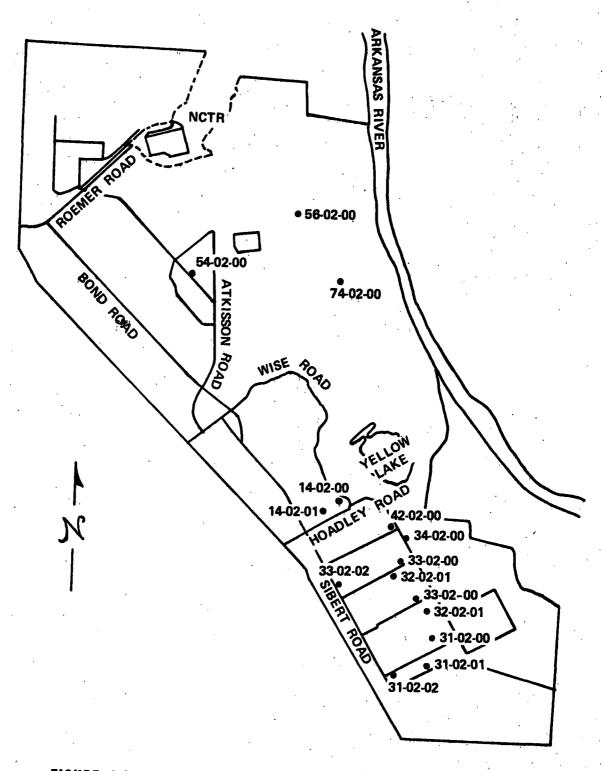


FIGURE 1-6. LOCATION OF WATER QUALITY MONITORING WELLS

2. Natural Resources

- a. Fauna. Terrestrial ecological surveys of PBA made by the Ecology Branch, Environmental Technology Division of Chemical Systems Laboratory, have indicated that most of the biological communities are healthy and normal.
- (1) Mammals. There are 35 species of mammals known to occur at PBA. The most common species are the white-tailed deer, cotton rat, white-footed mouse, and the fox squirrel. These and other mammals are listed in Appendixes E and F. There have been reports, but no capture records, of an endangered species -- the Mississippi Valley red wolf (Canis rufus gregori).
- (2) Birds. One hundred fifty-six species of birds have been recorded on the Arsenal. Two species, bobwhite and turkey, are upland game birds. A species list of birds is included in Appendix E. Two endangered species, the peregrine falcon (Falco peregrinus) and the red-cockaded woodpecker (Dendrocopus borealis) have been reported. The falcons were located in the wetlands of PBA. The woodpeckers were sighted in 1965. A ten acre tract of pines was set aside around the nest-site trees, but no sightings of the birds have been made since 1966.
- (3) Fishes. Appendix E includes the fishes known to be on or near PBA. This is not a complete list as the creeks and streams have never been adequately surveyed.
- (4) Reptiles and Amphibians. Fifty-nine amphibian and three reptile species have been recorded. They are listed in Appendix E.
- (5) Invertebrates. A list of invertebrate taxa collected in streams on PBA is given in Appendix E.
- b. Flora. The natural resources program claims 14,000 of the 15,000 acres in PBA. The remaining land is occupied by buildings, roads, railroads, parking and storage areas, walks, and pavements. Ten thousand acres are considered improved land, which includes 8,000 acres involved in timber stand improvement, 1,200 acres in erosion control programs, 600 acres of cleared land, 300 acres under weed control, and 200 acres of planted trees.

PBA is located on the border of two major climax situations in Jefferson County. Initially, the land was mostly forest; however, most of the timber had been cut prior to government acquisition in 1941. Presently 80% of the forested areas are in pine, resembling the pine-oak-hickory climax of the southwestern half of Jefferson County. In areas where all the trees have been removed, the main vegetation is bermuda grass, broomsedge, lespedeza, hop clover, dallisgrass, crabgrass, and needlegrass. Johnson grass is

abundant in open areas in the bottoms and along the Arkansas River. A list of vegetation found at PBA is contained in Appendix E.

3. Geological Resources

- a.! Physiography/Topography. PBA occupies a level alluvial terrace overlooking the Arkansas River in the west central portion of the Mississippi Embayment. The local relief of the terrace is less than 20 feet, except where surface streams have cut to a depth of 20 feet in some locations. A 30 to 50 foot high north-south bluff bounds the terrace on the east. Total relief on PBA is 150 feet from an elevation of 190 feet ms1 at the Arkansas River to an elevation of 340 feet ms1 in the north-western portion.
- b. <u>Geologic Formations</u>. Unconsolidated formations which outcrop on PBA are: quaternary alluvium deposited by the aggrading Arkansas River that occupies the narrow flood plain below the bluff and around Yellow Lake and quaternary terrace deposits underlying the bulk of PBA located above the bluff (see Figure I-7). Outcropping on the northwest and possibly along the western boundary are shales, muds, and sands of the Jackson Group. The surface cut on the Jackson Group is at a higher elevation with more local relief than the terrace surface. Paleozoic bedrock lies about 3,000 feet below the surface. Table I-5 shows the geologic section for PBA and vicinity. See also Appendix G.

TABLE I-5

Formation Name	<u>Age</u>	Remarks
Alluvium Terrace Deposits	Quaternary	Unconsolidated, water bearing
Jackson Group undifferentiated	Eocene	Largely impermeable, minor water in thin sands
Clairborne Group Cockfield formation Cook Mountain formation Sparta Sand	Eocene	Water bearing

Older deposits

Paleozoic bedrock

c. <u>Soils</u>. Surface soils at PBA range from clays, silts, to silty sands depending upon the environment of deposition. All types of material can be encountered at some depth in the subsurface although they are primarily silts, sandy silts, and clays (see Figure I-8).

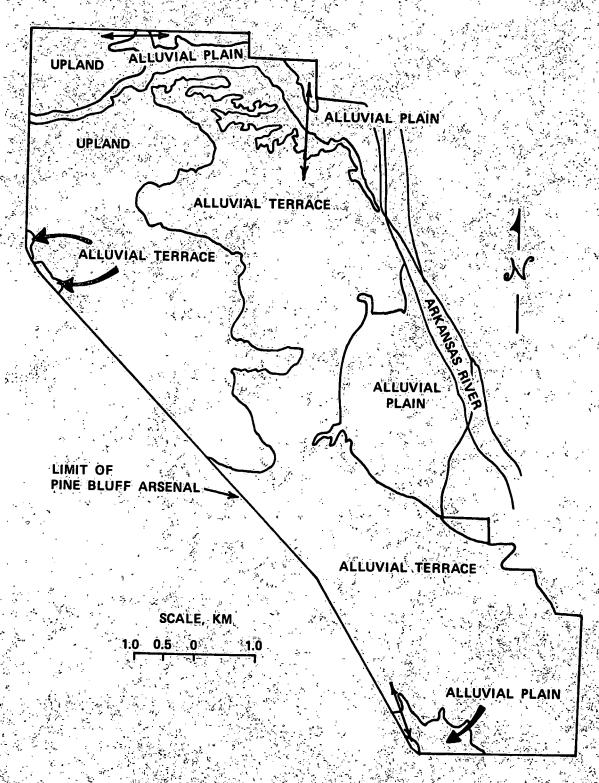
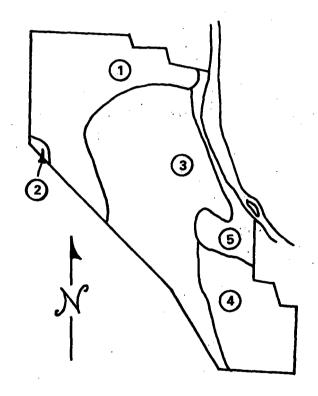


FIGURE 1.7. PINE BLUFF ARSENAL LANDFORMS



PINE BLUFF ARSENAL LEGEND:

- 1) ANGIE-SACUL (SAFFEL) SAVANNAH
- 2 CAHABA-SAVANNAH
- 3 AMY-PHEBA-SAVANNAH
- 4 HENRY-CALLOWAY GRENADA
- 5 CREVASSE-PORTLAND

FIGURE 1-8. SOILS TYPE MAP

There are five soil associations on PBA. The Angie-Sacul (Saffel)-Savannah association is located on the northern end of PBA. These soils are deep, moderately well drained, slowly and moderately slowly permeable, acid, and loamy. They consist of 35% Angie, 25% Sacul, 25% Savannah, and 15% inclusions of Amy, Ochlockonee, Iuka, Myatt, Cahaba, Susquehanna, and Pheba. Angie soils have grayish-brown fine sandy loam surface soil over yellowish-brown silty clay loam upper subsoil. Sacul soils have grayish-brown fine sandy loam surface soil over yellowish-red or red clay subsoil that is mottled gray in the lower part. Savannah soils have grayish-brown fine sandy loam surface soil over yellowish-brown loam or sandy clay loam subsoil that has a gray, yellow, and brown mottled fragipan in the lower part.

The Cahaba-Savannah association occupies a small niche on the western boundary of PBA. It is deep, well and moderately well drained, moderately and moderately slowly permeable, acid, and loamy. They consist of 45% Cahaba, 40% Savannah, and 15% inclusions of Angie, Amy, Pheba, and Sacul. The well-drained Cahaba soils have grayish-brown or brown fine sandy loam surface soil over yellowish-red or red sandy loam or sandy clay loam subsoil. The moderately well drained Savannah soils have already been described.

The Amy-Pheba-Savannah association occupies the central part of the Arsenal. These soils are deep, poorly to moderately well drained, slowly and moderately slowly permeable, acid, and loamy. They consist of 45% Amy, 25% Pheba, 20% Savannah, and 10% inclusions of Myatt, Cahaba, Angie, Sacul, and Ochlackonee. The poorly drained Amy soils have gray silt loam surface soil over gray, mottled silt loam or silty clay loam subsoil. The somewhat poorly drained Pheba soils have dark gray to grayish-brown silt loam or loam subsoil that has a fragipan in the lower part.

The Henry-Calloway-Grenada association lies on the southern end of PBA. These soils are deep, poorly to moderately well drained, slowly permeable, level to gently sloping, acid, and loamy. This association is made up of 40% Henry, 40% Calloway, 15% Grenada, and 5% inclusions of Falaya and Zachary soils, and gullied land. The poorly drained Henry soils have grayish brown or gray silt loam surface soil over gray, mottled silt loam or silty clay subsoil that has a fragipan. The somewhat poorly drained Calloway soils have grayish-brown silt loam or silty clay loam subsoil that has a fragipan. The moderately well drained Grenada soils have brown silt loam or silty clay loam upper subsoil and mottled gray and yellowish-brown lower subsoil that is a fragipan.

The Crevasse-Portland association occupies an area around Yellow Lake and a narrow strip running north along the east edge of the Arsenal. These soils are deep, somewhat poorly drained, rapidly to very slowly permeable, and acid to neutral in pH. The sandy and clayey bottom land soils are subject to frequent flooding. The association consists of 45% Crevasse,

30% Portland, and 25% inclusions of Rilla, Keo, Morgenfield, Latanier, Desha, and Perry. The excessively drained Crevasse soils have brown loamy sand surface soil overlying light yellowish-brown sand. The somewhat poorly drained Portland soils have dark grayish-brown silty clay loam to clay surface soil over dark brown to red, mottled clay subsoil.

II. CONTAMINATION ASSESSMENT

A. Industrial Operations

1. Historical Background

In 1941, Pine Bluff Arsenal was established for the manufacturing, loading, and assembly of various incendiary and chemical munitions. The original mission of loading magnesium and thermite types of incendiary bombs was expanded through the years to include the manufacture of agent, filling of chemical bombs, incendiary smoke munitions, and the filling of various munitions with chlorine, mustard and lewisite.

During the Korean War PBA produced incendiary bombs and clusters, smoke grenades, smoke pots and canisters, white phosphorus and FS shells (sulfur trioxide - chlorosulfonic acid solutions). Biological warfare operations were started in 1953. In 1961 a CS munition production facility was completed and in 1962 a BZ munition facility was put in operation. Appendixes H and I contain lists of buildings at PBA.*

2. Production Operations

Production at PBA can be grouped into three main categories: (1) Pyrotechnics (formerly incendiary), (2) Chemical manufacturing, and (3) Biological operations. These production categories are identified on Figure II-2.

a. Pyrotechnic Area. The pyrotechnic area is located in area 3, sections 1, 2, 3, and 4. Sections 1 through 3 are similar in layout; there are two plant units and each has two production lines. Colored smokes (red, yellow, green, and violet), M36 cluster, and CS facilities are scattered throughout the three sections. Primary facilities for handling colored smoke are buildings 33-530 and 33-630 which are used for filling/pressing of grenades and canisters, respectively. Other operations such as mixing, drying, storage, etc. are scattered throughout sections 1 through 3. The primary facility for handling the M36 cluster is building 33-530 wherein pressing, assembly, leak-test, and packout operations occur. Primary facilities for CS are buildings 31-630 and 32-640 for grenades and canisters, respectively. Other operations involving CS (mixing, drying, etc.) and the M36 cluster (mixing, primer/firing pin subassembly, etc.) are scattered throughout the three sections. Note: The M36 cluster facility was removed from Building 33-530 in 1972. No M36 cluster facilites are presently at PBA.

^{*}The process of locating individual facilities or buildings has been greatly simplified at PBA. Arsenal lands have been divided into numbered areas which are themselves subdivided into numbered sections. Each structure is then numbered to identify the area/section in which it lies. For example, building 31-630 is located in area 3, section 1, etc. (See Figure II-1.)

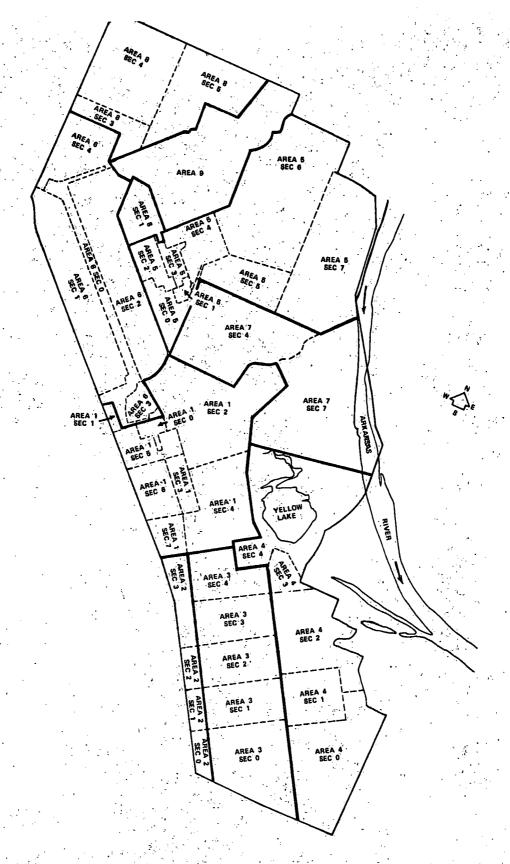


FIGURE 11-1 AREAS AND SECTIONS OF PINE BLUFF ARSENAL

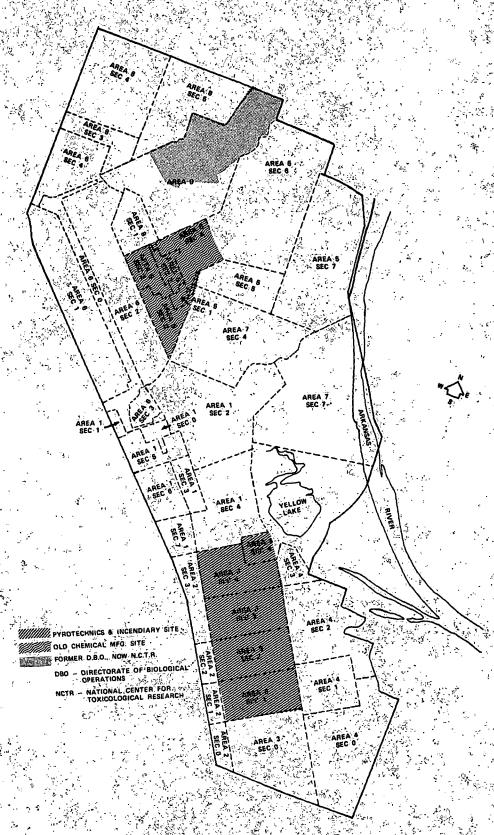


FIGURE 11-2 FORMER PRODUCTION SITES AT PBA

The HC smoke (white smoke) production area is located at the north end of the pyrotechnic area. Facilities are buildings 34-340 through 34-680 and consist of five production buildings and two support structures. Building 34-630, the primary building, has the capability to fill/press smoke pots. Building 34-860 is a storage igloo in the original HC smoke area.

Production facilities for the TPA-filled M74 rocket clip are concentrated in a minor portion of area 3, section 1. Primary facilities are building 31-540 for the fuze/clip subassembly operation and building 31-640 for fill/load assembly pack (LAP).

Former BZ production facilities are fenced off from other buildings. Primary facilities are building 32-530 for filling, loading, assembly, and packout and building 32-540 for agent production. Equipment for BZ production has been decontaminated and buried at the PBA landfill.

Building 32-070 was converted into a facility to impregnate clothing worn by personnel subject to exposure by chemical agents. The building was formerly a tool and die machine shop. Articles of clothing are treated in an aqueous suspension of polyvinyl alcohol, chlorinated paraffin, and biphenyl dichloro urea. A waste treatment study on this facility by AEHA, Report No. 24-044-73/76, dated 13 February - 21 March 1974, is included as Appendix J.

Buildings 34-101 through 34-220 constitute the WP filling facilities. Three wet fill lines and one dry fill line, empty/filled shell, inspection/packout, and demilitarization/rework areas are located in building 34-110, the primary building. Oven-testing as a phosphorus leak check is performed north of Building 34-110 in steam heated ovens. Some of the items filled in these facilities prior to 1974 are listed in Table II-1. A typical years production for 1972 is listed in Table II-2.

TABLE II-1. ITEMS FILLED IN WP FILLING FACILITIES PRIOR TO 1974

Items Filled on Wet Lines

Items Filled on Dry Line

Grenade, M34
Bomb, BLU-17/P, WP
Cartridge, 60-mm, M302
Igniter, AN-M23A1
Warhead, Rocket, 2.75 inch, M156 & XM67
Cartridge, 105-mm, M60E1 and M416
Cartridge, 4.2 inch, M348A1
Projectile, 5 inch, MK-14 and M5
Projectile, 155-mm, M110
Projectile, 175-mm, XM510E2
Launcher, CBU-12 and CBU-22

Warhead, Rocket, 2.75 inch, M156 Cartridge, 60-mm, M302 Cartridge, 81-mm, M375 Cartridge, 4.2 inch, M328 Cartridge, 105-mm, M60 and M416

TABLE II-2. SUMMARY OF MUNITION QUANTITY/QUALITY FOR FY 1972 AN OUTPUT LIST FOR A TYPICAL PRODUCTION YEAR

•				
End Item Description	Net Quantity Produced	No. Lots	No. Lots Temp/Perm Rejected	Inprocess Rejects
Bomblet, INC, M126	2,421,183	76		18,888
Cluster, M36E2	13,498	77		
Canister, 105mm, CS, XM8	141,839	22		2,183
Grenade, AN-M8	189,867	26		7,460
Grenade, Colored Smoke, M18	408,800	53	5	635
Grenade, M18 Green	216,056	31	1	1,082
Grenade, M18 Red	125,344	13		224
Grenade, M18 Violet	288,831	30	1	1,054
Grenade, M18 Yellow	557,739	62	1 .	1,797
Grenade, M34	21,888	1		61
Igniter, AN-M23Al	108,888	8	.	135
Projectile, 57mm, WP	26,156	. 2		41
Projectile, 81mm, WP	65,700	1		59
Projectile, 81mm, M375	24,894	4		288
Projectile, MK14, MOD 0	2,424	4		5
Starter, Fire, NP3, M2	1,250	1		2
Warhead, 2.75", WP	194,994	8		746
LAP Ctg, 81mm, M375	43,296	i	·	85
LAP Warhead, 2.75", w/Fuze, M423	2,453	1	'	
LAP Warhead, 2.75", w/Fuze, M427	319,668	32		1
LAP Projectile, 81mm, M375, WP	27,076	2		
LAP Rocket, 2.75", w/Warhead	2,453	2		
Miscellaneous	15,830	147		
TOTAL/YEAR	5,220,127	604	8	34,746

White phosphorus LAP facilities include buildings 44-100 through 44-121. The primary building (44-110) is able to receive WP filled items and to perform reworking, storage, maintenance, and assembly/packout operations.

b. Chemical Manufacturing Area. Mustard (H) and lewisite (L) manufacturing and filling operations were conducted in area 5, the chemical manufacturing area, from 1942 through December 1943.

In support of the mustard and lewisite operations, facilities for manufacturing chlorine and arsenic trichloride were constructed and operated from late 1942 until late 1943. Table II-3, obtained from historical records of PBA, shows amounts of materials produced through December 1943.

TABLE II-3. ACCUMULATIVE PRODUCTION FIGURES TO DECEMBER 1943

Mustard (H)	11,300	tons
Lewisite (L)	6,800	
Nitrogen Mustard HN-1		tons
Chlorine Chlorine	13,500	tons
50% caustic	13,500	ttons
M47A2 Bombs filled with H	215,581	each
M70 Bombs filled with H	120,000	each
M70 Bombs filled with L	128,750	each
4.2 inch shells filled with H	40,400	each

The original complex contained 168 buildings/structures (see Figure II-3). These facilities remained idle until about 1950 when Diamond Alkali and Chemical Company and ARK-LA Chemical Corporation leased the old chlorine manufacturing facilities, a boiler house, and warehouse space for storage of chlorine manufactured until November 1969 (Area 5, Sections 2 and 3). Pine Bluff Chemical Company (later Niagara Chemical Company) leased several buildings to manufacture DDT and chlorobenzene for commercial agricultural pesticides using the chlorine (Area 5, Section 4). The former mustard manufacturing facilities have been declared excess and many of the buildings removed. Facilities retained include: (1) building 53-220 and pit 53-225 to be used for the proposed Binary Munitions Facility; (2) tanks 53-150, 53-250, 53-350, and 53-450 for the proposed Bulk Mustard Disposal Facility; (3) ten buildings/structures for present/future use. Included in the latter group is the former H filling building (53-990) which is presently used for storage by the Directorate of Depot Operations. Excessed buildings still standing include two small buildings and a cafeteria. L production facilities have been declared excess. Buildings 54-140, 54-240, 54-340, and 54-440 (three-story concrete and tile construction) were the primary facilities for lewisite production. Building 54-340 was also used to produce nitrogen mustard for a short period of time. The buildings cannot be disposed of by the Corps of Engineers because the removal cost is greater than the salvage value and potential contamination. Building remaining from



FIGURE II-3 PANORAMA VIEW FROM WEST WATER TOWER IN AREA 5, LOOKING NORTHEAST SHOWING "H" FILLING BUILDING AND ALL BUILDINGS OF "L" SECTION (H-MUSTARD/L-LEWISITE), 12/4/43.

the H and L facilities (see Figures II-4, II-5, II-6, and II-7) and their surrounding lands are known or suspected of being contaminated with DDT and arsenic as well as H and L and have been placed "off-limits." Building 54-140 (one of the L buildings) was leased during the 1950's by Niagara Chemical Company for DDT production, an operation that led to widespread contamination of facilities and grounds with DDT. The foundations of buildings 54-270 and 54-325 were retained for storage of DDT contaminated soil and other wastes. See Figure II-8.

c. Biological Operations. Biological operations including agent fermentation, munitions filling/production, and laboratory support were conducted in area 9 at PBA. Some of the biological warfare materials produced between 1954 and 1967 included Brucella suis, Pasteurella tularensis, Bacillus anthracis, Botulinum toxin, Staphylococcal enterotoxin, Clostridium botulinum toxin, and coxiella burnetii. Bulk agents along with antipersonnel munitions filled with these agents and toxins were stored at the Directorate of Biological Operations (DBO). Igloos utilized to store biological materials were identified as numbers 85-010, 85-030, and 85-040. The operations of the DBO were terminated in November 1969. During 1971 all stocks of biological munitions, agents, and toxins were destroyed in accordance with approved demilitarization plans. The DBO facility was decontaminated and deactivated and in 1972 the entire complex of land, buildings, and equipment was turned over to the Food and Drug Administration who now operates it as the National Center for Toxicological Research (NCTR). NCTR is operated separately from PBA. Waste generated by the Center is monitored by NPDES permits. NCTR operations were outside the scope of this records search.

3. By-product Waste and Contamination

It is possible that each of the production areas has contributed extensively to the contamination of PBA. Personnel on the Arsenal have compiled a list of suspected contaminated sites including drainage ditches. See Appendix I (Environmental Assessment Report). Suspected contaminants, site locations, and periods of active contamination are provided in Figure II-10. Several additional areas/sources of suspected contamination identified during the Team survey are shown in Figure II-9. In the pyrotechnic area, a significant amount of material was lost during preparation and transfer of mixes and during the pressing and sealing of canisters. During clean-up operations, accumulated mixes were flushed into the drainage systems and subsequently into drainage ditches which ultimately discharge into other ditches that cross private property en route to the Arkansas River (see Appendix K, AEHA Report 24-002-73, dated 17 - 21 July 1972). During an eight-hour shift it is estimated that 117,000 gallons of waste water is discharged when all buildings are in operation. The pyrotechnic area is drained by Warbritton Creek and the Production Area Creek. There are 22 drainage ditches in areas 3 and 4 which have been identified by PBA as being contaminated. Figure II-10, item 32, identifies contaminated areas. A list of potential pollutants from the pyrotechnic complex is provided in Table II-4.



FIGURE II-4 PANORAMIC VIEW OF MUSTARD FILLING AND LEWISITE MANUFACTURING BUILDINGS 12/2/43



FIGURE II-4 PANORAMIC VIEW OF MUSTARD FILLING AND LEWISITE MANUFACTURING BUILDINGS 12/2/43



FIGURE II-5 LEWISITE MANUFACTURING BUILDING, JUNE 1977

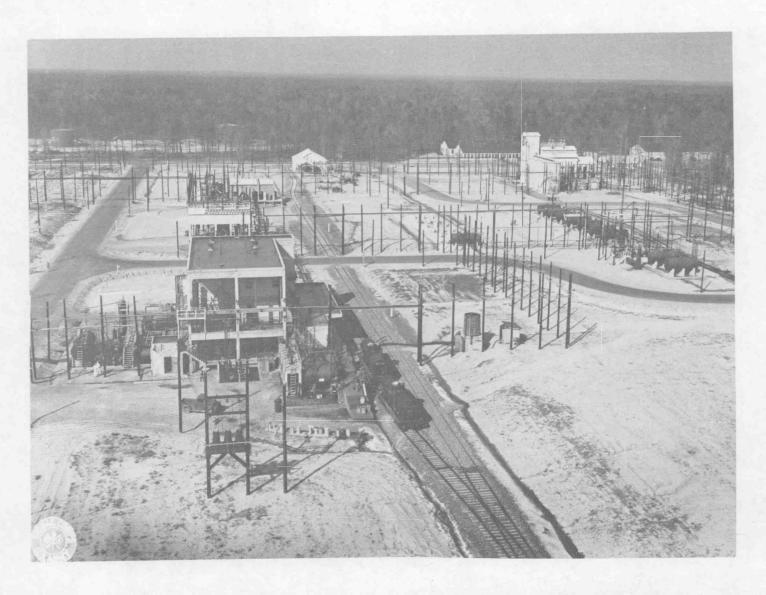


FIGURE II-6 PANORAMIC VIEW OF L AND AT MANUFACTURING BUILDINGS AT PBA, 12/2/43

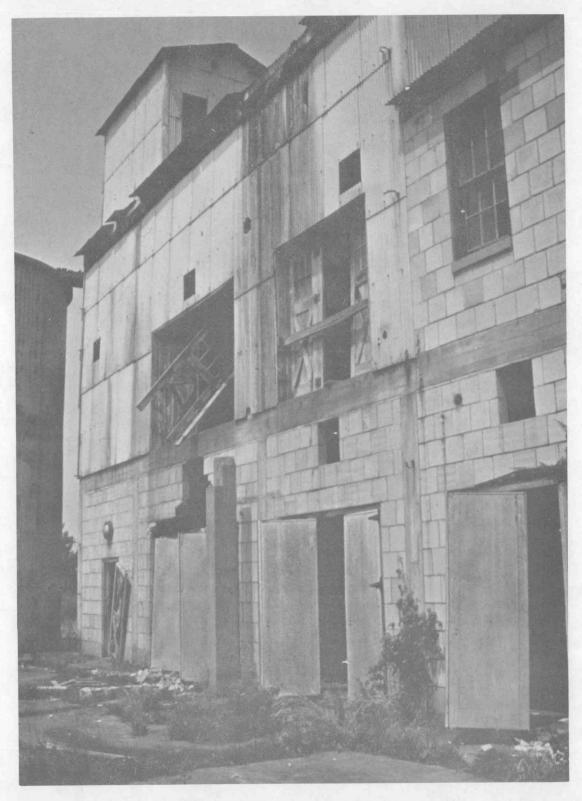


FIGURE II-7 ARSENIC TRICHLORIDE MANUFACTURING BUILDING, JUNE 1977

II-12

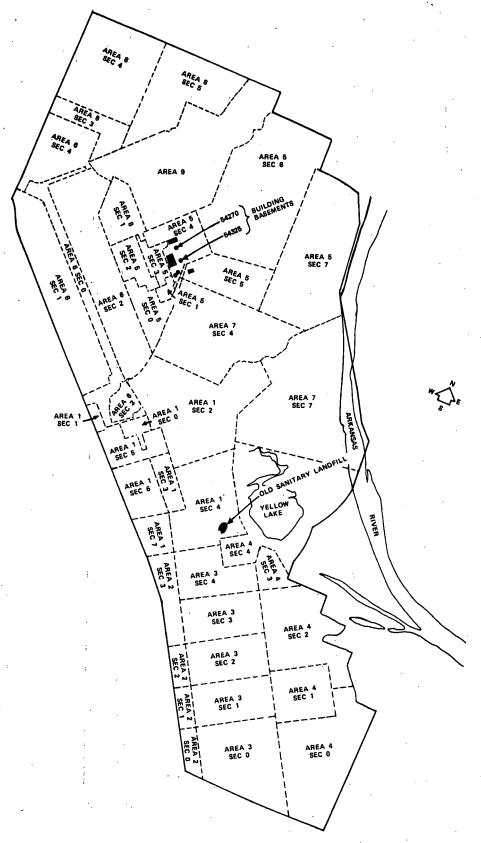


FIGURE 11-8. KNOWN AREAS OF DDT CONTAMINATION

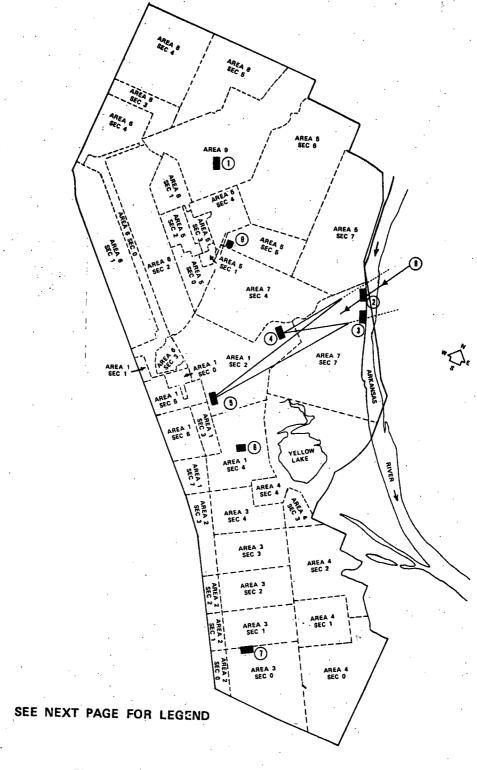


FIGURE 11-9. AREAS SUSPECTED OF CONTAMINATION

LEGEND

31

- 1. DBO BURIAL SITE: SLUDGE FROM DEMILITARIZED BW AGENTS. LOCATED BETWEEN POLES 9B 27 AND 9B 31 ALONG POWER LINE B, IN USE DURING 1971.
- 2. BLUFF OVER ARKANSAS RIVER: GENERAL DEBRIS, SUCH AS, WIRE SCREEN, CONCRETE FORMS, ETC., ON SURFACE.
- 3. OLD BURIAL PITS: LOCATED ALONG ARKANSAS RIVER NORTH OF SUSPECTED CONTAMINATED SITE NUMBER 12. THOUGHT TO CONTAIN JUST ABOUT EVERYTHING.
- 4. SHORT RANGE GUN EMPLACEMENT: POSSIBLE 4.2 INCH WP AND HE UNEXPLODED ORDNANCE WITHIN THE SURFACE DANGER ZONE, IN USE BETWEEN 1942 THROUGH 1944.
- 5. LONG RANGE GUN EMPLACEMENT: POSSIBLE 4.2 INCH WP AND HE UNEXPLODED ORDNANCE WITHIN THE SURFACE DANGER ZONE, USED DURING PERIOD OF 1942 THROUGH 1944.
- 6. OLD BURNING GROUND: USED 1942 THROUGH 1944 FOR NP DISPOSAL.
- 7. FORMER DEMILITARIZATION SITE: PRIMERS FROM M50 BOMBLET, IN USE FROM 1948 THROUGH 1950.
- 8. BOMBING FLIGHT PATH BETWEEN ARKANSAS RIVER AND BOMBING MAT: POSSIBLE UNEXPLODED BOMBLETS ALONG FLIGHT PATH.

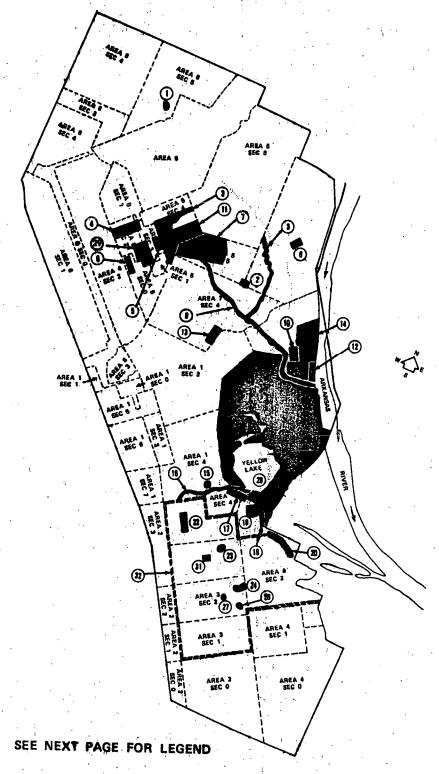


FIGURE 11-10. AREAS OF CONTAMINATION AT PBA

LEGEND

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
1	CONSTRUCTION WASTE	1955/1956	AREA 8, SEC 5. AREA ACROSS FROM BLDG 85-160 AND 85-161.
2 '	M6, CN, DM	1944/1948	AREA 5, SEC 6 & &. AREA NORTH OF WEBSTER ROAD, WEST OF INTERSECTION WITH DOOLITTLE ROAD. TEST SITE.
* 0° - 3.	ACID, AsC13 WASTE, DDT	1945/1948	AREA 5, SEC 4. NORTH AND WEST OF BLDG 54-500.
4	MUSTARD, INCENDIARIES	BURNED 1944/ COVERED 1946	AREA 5, SEC-2. ABANDONED BURNING SITE WEST OF THE INTERSECTION OF 504TH ST. AND AVE. 6242.
5	MUSTARD	BEFORE 1946	BLDG 53-990. BASEMENT AND NETWORK OF TUNNELS LOCATED BENEATH FIRST FLOOR, CURRENTLY FILLED WITH WATER.
6 .	INDUSTRIAL SOLID WASTE	BEFORE 1969	AREA 5, SEC 0. AREA SOUTHWEST OF ARKIS CHEMICAL MANUFACTURING AREA, 300 FT BY 1,300 FT.
7	MUSTARD, OTHER CONTAM- INATION SUSPECTED	BEFORE 1946	AREA 5, SEC 5. BARROW PITS ADJACENT TO SOUTH EDGE OF TOXIC STORAGE YARD AND THE TOXIC STORAGE YARD.
. 8	FLOATING HC SMOKE POTS	CURRENT USE	AREA 5, SEC 7. POND ON DOOLITTLE ROAD. TEST SITE.
. 9	MUSTARD	RAIN RUN-OFF	AREA 7, SEC 4. STREAM RUNNING FROM TOXIC STORAGE YARD TO ARKANSAS RIVER.

LEG (CONTINUED)

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
10	CS, PYROTECHNICS, MUNITIONS, SMOKES, INCENDIARIES	CURRENT USE	AREA 7, SEC 7. DEPOT'S BURNING AND DEMOLITION AREA.
11	ARSENIC, MUSTARD, LEWISITE, DDT	BEFORE 1956	AREA 5, SEC 4. EAST OF BLDG 54-500, 507TH ST. TO ATKISSON ROAD. 47 BUILDINGS, STRUCTURES, SLABS AND PITS, INCLUDES FOUNDATIONS OF FORMER BUILDINGS 54-270 AND 54-325.
12	LEWISITE, PHOSGENE, MUSTARD FILLED AMMUNITION AND COMPONENTS	BEFORE 1948	AREA 7, SEC 7. ABANDONED BURNING PITS SOUTH—WEST OF THE ARKANSAS RIVER AND EAST AND SOUTHEAST OF BOMBING MAT.
13	PYROTECHNICS	APPROX 1960	AREA 7, SEC 4. ABANDONED BURNING SITE NORTH-WEST OF McCOY ROAD, APPROXIMATELY 1,000 FT NORTH OF INTERSECTION OF WISE AND McCOY.
14	WP TRENCH MORTAR, PYRO- TECHNICS, DUDS (POSSIBLY ALL CONTAMINANTS FOUND AT PBA)	1943/1948	AREA FROM BLDGS 42-410 & 44-301 TO BOMBING MAT. PROOF TEST AREA INCLUDING YELLOW LAKE AND THE AREAS NORTH AND EAST OF YELLOW LAKE.
15	GARBAGE, DDT	1948/1968	AREA 4, SEC 4. SANITARY FILL 600 FT NORTH OF INTERSECTION OF HOADLEY AND McCOY ROADS.
16	WP	CURRENT USE	AREA 4, SEC 4. STREAM RUNNING FROM WP POND TO YELLOW LAKE.
17	PYROTECHNICS, INCENDIARIES, COLORED SMOKES, CS, CS2, CN, DM, HC, AND MUNITION SHELL CASTINGS	CURRENT USE	AREA 4, SEC 4. OSO TEST RANGE, 300 FT BY 1,400 FT, NORTH OF BLDG 44-300.
18	GARBAGE AND INDUSTRIAL WASTE	1968 TO PRESENT TIME	AREA 4, SEC 3. SANITARY FILL NORTH OF McCOY ROAD, EAST OF DILLY FARM.

LEGEN_ (CONTINUED)

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
19	TRASH	CURRENT USE	AREA 4, SEC 3. FACILITIES BURNING PIT.
20	WP AMMUNITION		AREA 4, SEC 2. BURNING AND DEMOLITION AREA FOR DEPOT, NORTH OF McCOY ROAD.
22	WP, CONSTRUCTION DEBRIS	1944/1970	AREA 3, SEC 4. OLD 15 INCH WP LINE FROM BLDG 34-170 TO THE SOUTHEAST CORNER OF BLDG 34-110.
. 23	SMOKE GRENADES	CURRENT USE	AREA 3, SEC 3 PRODUCTION TEST AREA.
24	THERMITE WASTE FROM BZ POND	BEFORE 1951	AREA 3, SEC 2. AREA SOUTHWEST OF STOKES ROAD AND 400 FT SOUTH OF THE INTERSECTION OF EVERETT DRIVE.
26	THERMITE, HC, INCENDIARY, COLORED SMOKE	CURRENT USE	AREA 3, SEC 2. AREA AROUND BLDG 32-014.
27	THERMITE WASTE FROM BZ POND	BEFORE 1951	AREA 3, SEC 2. AREA EAST OF BZ POND.
28	PHOSPHATES DISSOLVED IN WATER OF YELLOW LAKE	CURRENT USE	YELLOW LAKE. SLUDGE AND WATER OF YELLOW LAKE.
29	SODIUM CHLORIDE	BEFORE 1969	AREA 5, SEC. AREA BOUNDED BY 502 & 504 STS. AND AVE. 51
31	SMOKE MUNITIONS RESIDUE	CURRENT USE	AREA 3, SEC 3. QC TEST SITE.
32	· ,		AREAS 3 AND 4. TWENTY-TWO DRAINAGE DITCHES.

^{*} NUMBERS 21, 25, AND 30 NOT USED.

TABLE II-4. POTENTIAL POLLUTANTS FROM THE PYROTECHNIC COMPLEX

Acetone **Hexachloroethane** Acid, Hydrochloric Ink Acid, Sulfuric Iron Oxide Aluminum, Powder Kerosene Auramine HC1 Lacquer Barium Nitrate Lactose Benzanthrone Magnesium Carbonate Black Powder Nitrocellulose BZ Agent Paint Thinner Castor 011 Particulate Charcoal Phosphoric Acid CN Agent Potassium Chlorate Cornstarch Potassium Nitrate CS Agent Primer Cord Decon Solutions (Danc, DS-2, STB, HTH) Red Lead (Lead Oxide) Detergents. Silicon Dextrin Sodium Bicarbonate Diatomaceous Earth Sodium Hydroxide DM Agent Sugar Dye (reds, green, yellow, violet) Sulfur Enamel Titanium Graphite Trichloroethylene Gum, Arabic, 8% in H₂O White Lead HC Mix Zinc Heptane Zinc Oxide

Wastes generated in the white phosphorus area include steam condensate, "phossy water" from direct contact with molten phosphorus, and other wastewaters such as floor washing, etc. These waters (with the exception of steam condensate) are high in elemental phosphorus, phosphates, and sodium. White Creek receives wastes from shop and production areas and drains them into Yellow Lake (Figure II-10). Disturbing the waters of this creek brings up fine solids from the creek bed that produce a white smoke upon exposure to air due to the presence of white phosphorus in the solids.

The area surrounding the old chemical manufacturing area is probably the most heavily contaminated area on the Arsenal. The production of mustard, lewisite, sulfur monochloride, chlorine, and arsenic trichloride have resulted in contamination of many buildings and their surrounding properties as a result of spills and early practices of indiscriminate disposal. In addition, Triplett Creek, which drains not only the manufacturing area but also the Toxic Storage Yard, is also contaminated. Lewisite production, for example, provided a sludge which contained arsenic trioxide, mercurous chloride, and organic polymers. Disposal procedures used for these materials are unknown.

Outleasing of facilities during the early 1950's for the production of DDT (building 54-140 was the primary building) resulted in contamination of the entire manufacturing area, the surrounding streams, several dump areas, and an old sanitary landfill. The results of a comprehensive study conducted on the DDT problem by AEHA may be found in Report 99-065-75/76, dated 28 - 31 July 1975, and attached as Appendix L.

During the years of DBO operations (1953 to 1969), waste products routinely produced in the manufacture/handling of BW materials were sterilized by either heat treatment or incineration prior to discharge into the sewer system. The sewer empties into the Eastwood Bayou which drains the northern part of the Arsenal and subsequently discharges into the Arkansas River. After the closure of DBO, materials stored in the igloos were removed and the igloos were decontaminated. During this period the industrial and sanitary sewers were combined. The BW organisms taken from storage were destroyed by heating them at 300°F for 10 minutes. Resulting wastes were sent to a conventional sewage treatment plant for biodegradation. Effluent from the sewage treatment plant was concentrated in a lined evaporation pond. Sludge from the pond was put on the ground along power line B right of way between poles 9B27 and 9B31 and disked into the soil. (See Appendix M.) Other materials/equipment were decontaminated by heating them in a smelter in building 85.

B. <u>Laboratory Facilities</u>

Building 54-500 was utilized during the earlier days of lewisite manufacturing as an analytical laboratory and it was later used as an administrative building for the facilities engineers. Presently the structure is unoccupied and is suspected of being contaminated with mustard, lewisite, arsenic and DDT in the drainage network.

There are three active laboratory buildings at Pine Bluff. Buildings 32-130 and 32-150 perform analytical and physical testing, respectively. They are located in the northeast part of area 3, section 2. The Product Assurance Directorate (PAD) Laboratory is a well equipped facility housed in building 34-111. Work performed in the PAD Laboratory includes: product acceptance, surveillance, control, and special investigative testing. Materials analyzed in the PAD Laboratory are listed in Table II-5. Radiographic non-destructive inspection is performed in the X-ray Laboratory (building 34-111) on munitions ranging in size from small items to 155mm projectiles. White phosphorus and liquid filled munitions; smoke/incendiary grenades, pots, and rockets; along with warheads and projectiles from the LAP lines receive this type inspection. Special agent testing (BZ, mustard, etc.) is also performed in this Laboratory.

Ancillary test facilities include the following: In building 44-125 there is a pendulum device for free-fall testing of M69 and M74 incendiary

bombs. Electronic equipment for testing fuzes, grenades, etc., are located in building 44-330. A wind tunnel used to test CS and BZ products disseminated in a solid micropulverized state or in a smoke cloud is located in the Agent Return Test Facility, building 32-535. Building 44-330, located at Dilly Farm near Yellow Lake, is a proof/test facility that provided controlled temperature conditions and fuze testing. Deep freeze, low temperature, and high temperature aging equipment are housed in building 31-750, the First Article Inspection Station. A drop tower, structure 32-690, permits testing of AN-M50 and M126 bombs from heights up to 40 feet.

TABLE II-5. MATERIALS INCLUDED FOR ANALYSIS AT PAD LABORATORY

Acids Adhesives and Adhesive Tape Alkalies Aluminum Bleach ΒZ Casein Charcoal Chlorates CS Dves G1 ue Hexachloroethane Impregnite Incendiary and Smoke Mixes Iron Oxide Molasses Residum Mustard Gases

Oils Paint, Lacquers, and Stencil Inks Pettman's Cement Pottassium Chlorate Red Lead Silicon Soaps Sugar Sulfur Thickener Titanium Vesicant Detector Crayon Vesicant Detector Papers Waterproof Liners White Phosphorus Yeast Zinc Oxide **Others**

C. Field Test Ranges/Sites

Eight test areas used in the past for chemical munitions have been located on the Arsenal (see Figure II-11): A pond on Doolittle Road (area 5, section 7) for testing smoke pots; the burning and demolition area southwest of the bombing mat (area 7, section 7) for items manufactured by PBA or stored by the Depot; an alternate site north of the intersection of Wise and McCoy Roads (area 7, section 4) for testing/burning CS when Wind conditions preclude use of site area 7, section 7; a QSO test range north of building 44-300 (area 4, section 4) at Dilly Farm on the bluff at Yellow Lake used for any test item except CS; a production test area (area 3, section 3) for smoke grenades; a drop tower (building 32-014, area 3, section 2) for thermate, incendiary, HC and colored smoke munitions; a QC test site (area 3, section 3) for HC and colored smoke; and a concrete mat for air drop testing of bombs and a range for testing M74 rockets and M47 grenades (area 7, section 7).

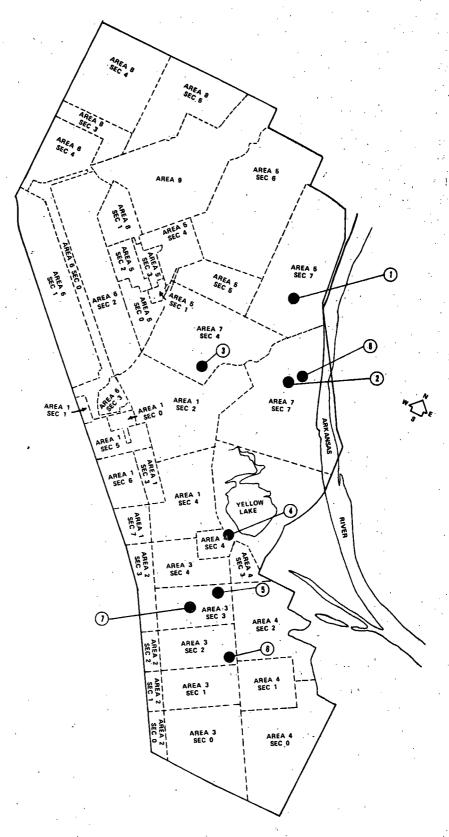


FIGURE 11-11. LOCATION OF TEST SITES

It is estimated that 0.2% of all materials produced at PBA were tested. Another indication of the amount of testing that has been done at PBA can be seen at the QC test site at Dilly Farm where the bank surface, measuring approximately 90 feet wide by 20 feet deep, has been extended approximately 20 feet towards Yellow Lake with fill consisting of test materials.

The Arsenal has one rifle range (area 1, section 2) located off of McCoy Road at the end of Turner Road which is used for weapon familiarization only.

D. CBR Burial Sites/Disposal Areas

Historical documentation collected during the Team survey revealed that at least five burial pits, located south of the Toxic Storage Yard, were used extensively for the disposal of mustard filled munitions and containers. Included were items such as 55 gallon drums, ton containers, M2 shells, 4.2 inch shells, and M70 and M47 bombs containing mustard agent. In 1955 PBA opened the pits and demilitarized the containers/munitions, decontaminated the pits with STB, and refilled them with dirt. Historical photographs of the clean-up operations are included as Appendix B. Recent soil tests show that the area south of the Toxic Storage Yard is heavily contaminated with thiodiglycol, a decomposition product of mustard.

The Directorate of Depot Operations has the responsibility for the disposal of contaminated wastes at PBA. It has been estimated that there are approximately 200 pounds per week of munition wastes alone that require disposal. These materials were demilitarized by open-pit burning in one of two major sites. Munition waste is now held for future disposal when the pollution abatement facilities are completed in CY79. The south burning area is used for the disposal of WP, pieces of fuse material, and CS in pyrotechnic mixture. Materials burned in the north open-pit burning area include contaminated construction and laboratory materials, explosives, smoke grenades, incendiaries, etc., but does not include WP.

Burning of explosives in the past led to wide-spread scattering of munition fragments; consequently, screened enclosures (see Figure II-12) were constructed to contain flying debris from exploding munitions. It was reported that German World War II rounds containing mustard agent were involved in one incident. The mustard rounds were recovered, deactivated, and decontaminated before burial.

E. Storage of Toxic/Hazardous Materials

PBA has four areas designated for the storage of chemical and high explosive materials. These areas are identified as the bomb storage magazine area, the Toxic Storage Yard (TSY), and the north and south igloo storage areas.

The bomb storage magazine area is located in area 4, section 1, and consists of 72 structures which are used exclusively as warehouses. The TSY



FIGURE 11-12. SCREENED ENCLOSURE FOR DETONATION OF EXPLOSIVES AT PBA

is located in area 5, section 5; it has four warehouses in addition to 89 open chemical storage racks. The north igloo area has 65 reinforced concrete igloos; it was formerly a CG Exclusion Area before termination of the installation's biological operations. It is presently designated a Chemical Limited Area for the storage of chemical surety materials. The south igloo area is subdivided into two sections. One section, designated a Controlled Area, has 192 reinforced concrete igloos and it is used primarily for the storage of conventional munitions. The other section, designated a Chemical Limited Area, is used for the storage of surety material and has 8 reinforced concrete igloos.

There are no radiological or biological materials stored at PBA. However, there are munitions, ton containers, identification kits, etc., stored there that contain GB, VX, BZ, and HT/HD agent(s) in addition to standard munitions.

F. Support Activities

1. Water Supply

All water requirements for PBA are fulfilled utilizing the deep well systems described earlier. An AEHA Water Quality Engineering Survey number 24-002-73 points out that slurry from settled and filtered backwash solids from the chemical area water treatment system was being discharged to natural surface drainage. A subsequent Army construction (MCA) funded project for the modification of solids disposal, incorporating the use of sludge lagoons to contain the slurry, has since been completed. See Appendix K.

2. Waste Disposal

Waste from PBA is in two categories, solid and liquid. Solid waste disposal will be discussed under Sanitary Landfill. Liquid waste disposal includes both industrial and sanitary sewage.

There are two separate collection systems at PBA -- sanitary and industrial. There are also two sewage treatment plants -- the incendiary bomb filling (IBF) area sewage treatment plant and the area 5 sewage treatment plant. The collection systems and locations of these plants are shown in Figure II-13.

The maximum capacity for the IBF plant is 2,000,000 gallons per day. The average flow for a typical period (January to July 1972) was 75,000 gallons per day. This plant receives sanitary sewage from the administrative area, depot operations area, salvage yard, housing area, white phosphorus area, and pyrotechnic area. Effluent from the primary treatment

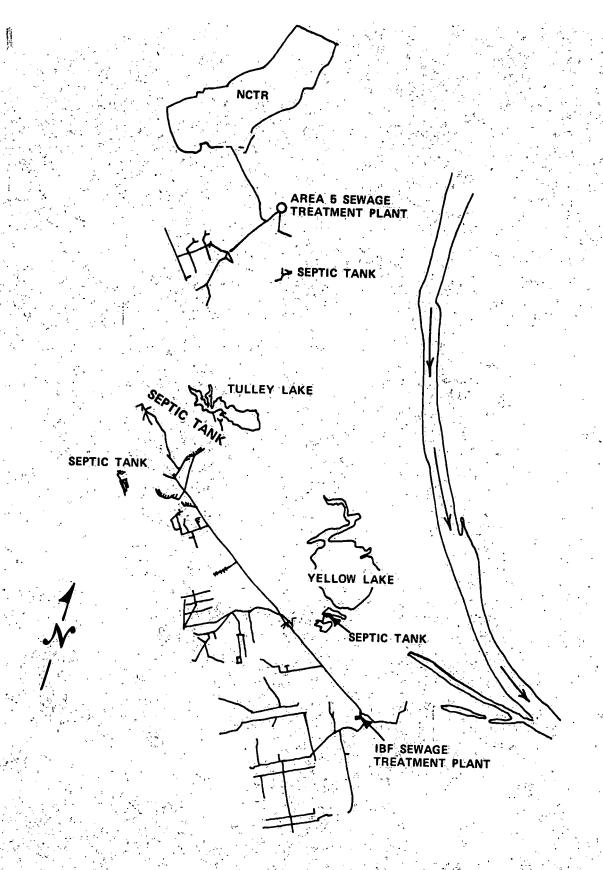


FIGURE 11-13. SANITARY SEWER AND COLLECTION SYSTEM PINE BLUFF ARSENAL

is then given a secondary treatment by pumping it to an oxidation pond. Effluent from the pond is chlorinated and discharged into Production Area Creek.

Area 5 (chemical area) sewage treatment plant has a capacity of 1,000,000 gallons per day. Its average flow in 1972 was 45,000 gallons per day. The plant receives sanitary and industrial waste from the NCTR and sanitary waste from area 5. The NCTR sanitary wastes are conveyed directly to the plant. The NCTR industrial wastes are conveyed separately to an equalization pond and, when elevated pH is measured, sulfuric acid is added to the waste just before it enters the pond. The pond effluent enters the NCTR sanitary sewer approximately one-half mile from the sewage treatment plant. Area 5 sanitary waste is conveyed directly to the treatment plant. Effluent from the primary treatment is given a secondary treatment consisting of an Infilco filter and a 20-acre oxidation pond. The effluent from the oxidation pond is then chlorinated before being discharged into Triplett Creek. See Appendix N.

In addition to these two treatment plants five septic tanks are used in remote areas to provide treatment for domestic wastes.

There are three types of industrial wastes at PBA that receive no treatment. These are pyrotechnic area wastes, white phosphorus wastes, and contaminated area runoff. Currently wastewaters associated with the pyrotechnic production activities are discharged directly to surface streams. Wastes from the white phosphorus production area flow directly to a series of settling basins and then into White Phosphorus Creek. All storm runoff waters at PBA flow into open ditches. These ditches drain into the Arsenal streams and eventually reach the Arkansas River. Runoff occurs from previously identified contaminated areas that have been used for disposal of chemical agents, pesticides, trash, white phosphorus, and other wastes. As long as these areas exist there is a possibility that runoff from the areas may contain pollutants. See Appendix K. Industrial Waste Treatment Facilities presently under construction are scheduled for completion during CY79.

G. Land Use Factors

Pesticide/Fertilizer

A pesticide program of sorts has been in existence since the activation of the Arsenal. A formal preventive program was initiated in March 1970. A summary of this program is contained in Table II-6.

An herbicide program began in 1960 with the application of polyborochlorate on railroad right of ways. In 1966, Urex II Monuron was substituted for polyborochlorate. Between 1969 and 1971, road shoulders were treated with the herbicide polyborochlorate. In 1962, 1964, and 1972

the application of two pounds per acre of 2,4,5-T and 2,4-D in a 50/50 ratio was used in the igloo area. The 2,4,5-T was used continuously from 1962 to 1971 in selected areas.

Between 1969 and 1972 golf course fairways and administrative area grounds were treated with monosodium methyl arsenate. Since 1968, vegetation around fire hydrants, culvert headwalls, and steam lines near the ground have been treated with a solution of monoborochlorate. In 1963, a program to kill diseased and undesirable species of trees was initiated; this consisted of a 2,4-D injection directly into the tree.

After 1972, the herbicide program, except for the railroad right of ways, was included in the Arsenal vegetation control contract. The herbicides used in this program are included in Table II-6. Since 1971, the application of herbicide on railroad right of ways has been contracted to firms specializing in this type of work. No Standing Operating Procedure for herbicide and pesticide application exists.

Fertilizer is used annually on all improved grounds. A normal application consists of 20-10-10 (20 pounds of nitrogen, 10 pounds of phosphonic acid, 10 pounds of potash) at a rate of 300 pounds per acre per year. New landscape plantings are fertilized with a 10-20-10 fertilizer.

2. Sanitary Landfills

Solid waste at PBA is separated into salvable, non-salvable, and contaminated waste. Salvable waste is hauled to the Salvage Yard for disposition. Non-salvable waste is hauled to a landfill site by a contractor. Contaminated material is collected and disposed of by the Depot Operations Group. See Appendix O.

PBA generates solid waste at an estimated rate of 3,200 cubic yards per month (uncompacted). The present sanitary landfill is located on the Arkansas River terrace along the east-central border of the Arsenal south of Yellow Lake. The 6.5 acre site, of which .75 acres have been filled, employs a trench method of operation. It is being filled at an average rate of .27 acres per year and has a life expectancy of 20 years. Waste delivered to the site is continually spread and compacted. After being compacted, six inches of cover material is placed over the refuse daily.

Several old pit areas were identified on PBA. These are located in Figure II-14. No known contaminants were placed in the pits which contain old lumber and construction debris. The pits located east and west of the firing pads were used for burning powder and munition wastes. See Appendix P.

TABLE II-6. SUMMARY OF HERBICIDE AND PESTICIDE APPLICATIONS AT PBA

Herbicide/Pesticide* Herbicides	Used for Control of	Where Used
Monosodium Methylarsonate	Dallisgrass	Golf course and administrative lawn
Bromacil	Conifer & all other vegetation	Igloo area 5, bomb storage magazines, electrical substations, TSY, fences, road shoulders, etc.
2,4-D; 2,4,5-T mixture	Broadleaf vegetation	Igloo areas
Pesticides		
Chlordane, 2% spray	Termites and ticks	Admin & housing area lawns & termite infested bldgs
Chlordane, 5% dust	Ants	Ration storage areas
Diazinon, 1/2% spray	Roaches	Food service and storage areas
Diazinon, 2% dust	Roaches	Military areas only
Duraban, 1/2% spray	Roaches	Food service areas
Malathion, 5% spray	Mosquitoes	Mosquitoes production area
Sevin Dust, 1% dust	Mosquitoes	Mosquitoes production area
Warfarin, 1/4% in grain	Rats	All food storage areas and food service facilities
Baygon, 1% dust	Roaches	All food storage areas and food service facilities
Pyrethrum aerosol, .6% Pyrethrum Insecticide, .04% Pyrethrum Ryonia Pyrethrum BP 300	Flies and roaches	All food storage areas and food service facilities
Roost-No-More	Birds.	Production areas

^{*}The use of trade names in this report does not constitute an official endorsement or approval of such commercial products. This report may not be cited for purposes of advertisement.

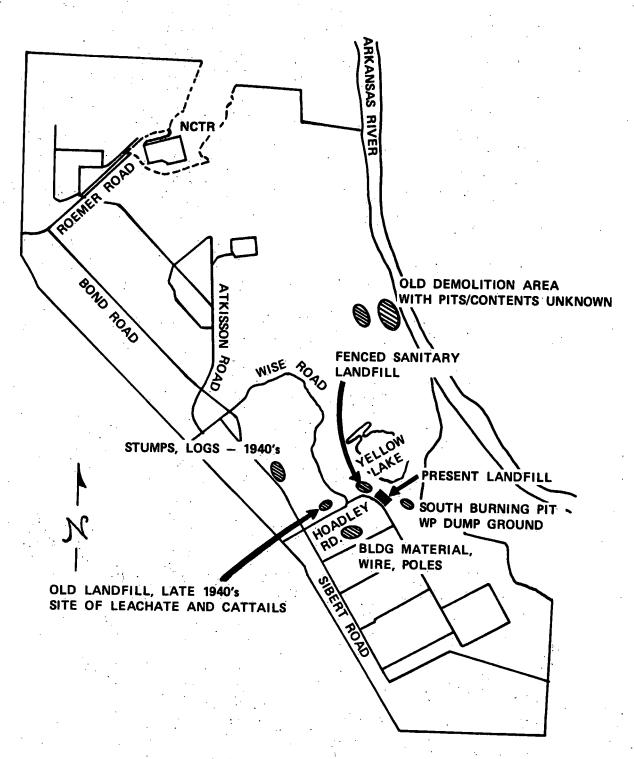


FIGURE 11-14. LANDFILL SITES

H. Geological Migration Potential Time/Distance Relationships

Little data is available on the percolation of water from the surface to the shallow water table or groundwater. Average permeability values derived by the US Department of Agriculture are low, implying that only small amounts of rainfall percolate through the upper soil to the groundwater. Minimum permeability values indicated by USDA for the upper six feet of soil in the old ARKLA Plant area vary from 0.2 to 0.6 inches per hour.

An AEHA Water Quality Geohydrologic Consultation, number 24-004-74, mentions a mean velocity of 25 feet per year for horizontal movement in the shallow water table. This velocity, referred to also under Subsurface Water Quality, was based on a single estimate.

A hydrogeologic sampling program currently being conducted at PBA by the Waterways Experiment Station should yield more information on this subject. See Appendix Q.

I. Environmental Indications

1. Land Indicators

Several closed disposal sites do not have an adequate thickness of final cover. In some cases water has infiltrated and exposed refuse, producing numerous leachate springs around these sites. One of the leachate springs is located at the foot of an abandoned landfill area northeast of the white phosphorus settling basins. There are uncrushed barrels and glass jars lying exposed on the surface. The spring is surrounded by a growth of cattails. A reddish-colored leachate has filtered downslope from the spring. No vegetation grows where the red leachate has flowed. See Appendix K.

2. Waterways Indicators

Results of aquatic surveys at PBA have shown that fauna lists for parts of Triplett Creek are restricted to a few species which are tolerant of the identified pollutants (DDT, arsenic, lead, and thiodiglycol). Triplett Creek receives drainage from old chemical sites, toxic waste burial sites, and an old industrial landfill.

An Edgewood Arsenal Technical Report, number EO-TR-76077, "Effects of Elemental Phosphorus on the Biota of Yellow Lake," indicates that elemental phosphorus concentrations could be used to predict species diversity. This diversity was highly correlated with the abundance of a macroinvertebrate (Limnodrilus hoffmeisteri). This relationship could be further distinguished as elemental phosphorus concentrations which are toxic, inhibitory, or stimulating to certain species. See Appendixes R and S.

III. FINDINGS

- A. Pine Bluff Arsenal is contaminated with hazardous wastes resulting from various operations conducted at the Arsenal from 1942 to the present both by government agencies and by industrial concerns that leased portions of the facility. Potential contaminants identified from the search of records are DDT, arsenic, white phosphorus, barium, zinc, mustard, BZ, riot control agents, pyrotechnic materials, and industrial wastes with their associated breakdown products.
- B. Sterilized biological waste was disced into the soil in a field on the property deeded to the National Center for Toxicological Research (NCTR). The buildings presently used by NCTR were formerly the facilities of the Directorate of Biological Operations (DBO) at PBA.
- C. Many test areas at PBA may contain unexploded ordnance (UXO). The UXO potentially consists of high explosive rounds, mustard rounds, pyrotechnic munitions (WP, HC, smoke, colored signals), and riot control devices (CS and CN).
- D. Radiological materials were not developed, manufactured, stored, tested, or disposed of at the installation.
- E. Lethal chemical agents (mustard and lewisite) were manufactured at PBA and mustard agent is presently stored at the Toxic Storage Yard (TSY). Other items in storage at the TSY include War Gas Identification Sets, riot control agents, decontaminants and FS. GB and VX are stored in igloos in the ammunition storage area. BZ is stored in three igloos in the ammunition storage area.
- F. Groundwater and the subsurface soil is contaminated in many areas of the installation. Thirty-two sites within the boundary were evaluated by sampling and analyzing for DDT, sodium, barium, arsenic, mercury, lead, zinc, mustard, lewisite, CS, CN, DM, dyes, hexachloroethane, and white phosphorus. Twenty-nine of the sites had at least two or more contaminants at concentrations in excess of critical threshold values established by a team of scientists at the Chemical Systems Laboratory.

IV. CONCLUSION

Current known areas of contamination were substantiated and additional suspected areas were located and documented. PBA personnel were advised of the suspected areas during the Team's exit briefing.

V. RECOMMENDATION

The preliminary surveys presently being conducted at PBA should continue because there is a strong potential of contaminant migration.

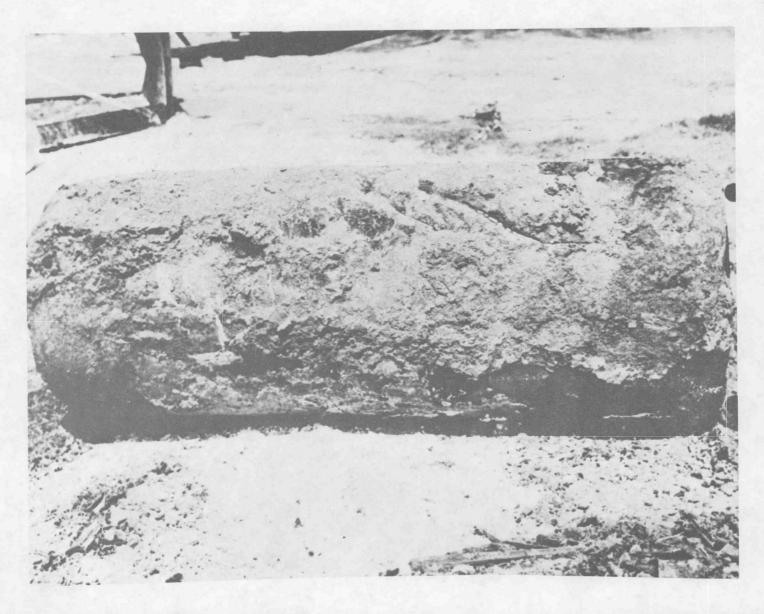
APPENDIX A
KEY PERSONNEL INTERVIEWED

APPENDIX B

PHOTOGRAPHS



A STACK OF 4.2 SHELLS THAT HAD BEEN REMOVED FROM FIRST MUSTARD PIT. (28 APRIL 55)



EMPTY ONE TON CONTAINER, "D" TYPE, THAT WAS REMOVED FROM SECOND PIT. (MUSTARD PIT AREA) (3 MAY 55)



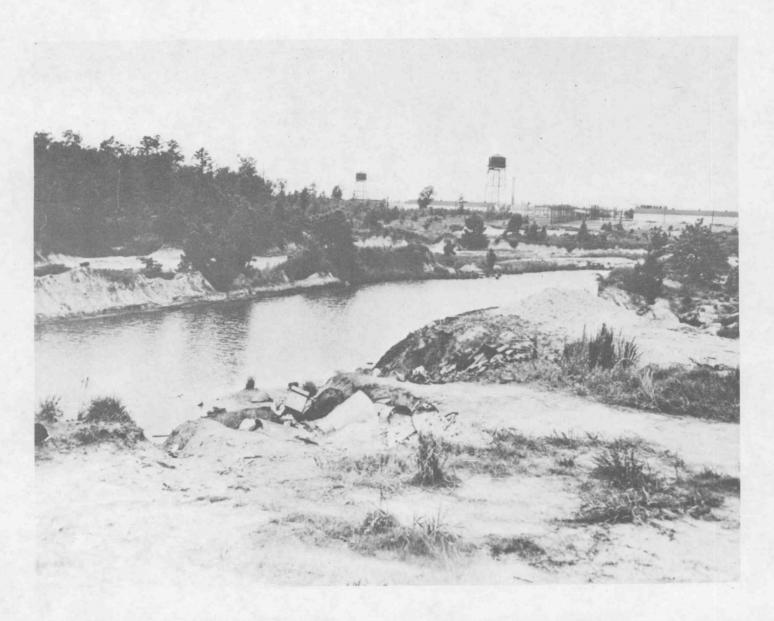
THIRD PIT BEING OPENED IN MUSTARD PIT AREA. (1 JUNE 55)



A SIDE VIEW OF MUSTARD PIT AREA (FOURTH PIT) SHOWING A PORTION OF M47 H FILLED BOMBS AND CONTAMINATED WOOD. (24 JUNE 55)



A VIEW OF THE ENTRANCE OF THE FIFTH MUSTARD PIT SHOWING BOXES OF DM M2 CANDLES. (12 JULY 55)



VIEW OF END OF PITS LOOKING INTO BORROW PIT. WATER FILLED PIT CONTAMINATED WITH ? (10 MAY 54)



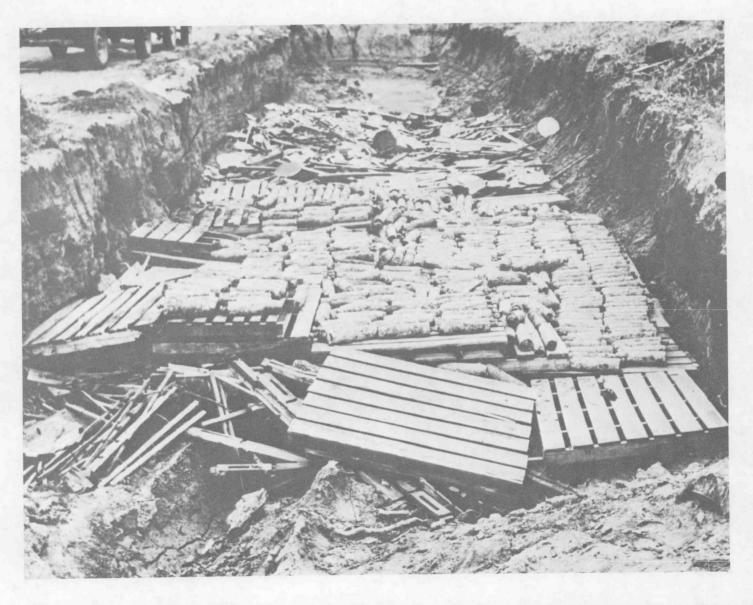
VIEW OF SCRAP AND BOMB, M47, H CONTAMINATED STORED INSIDE TOXIC GAS YARD. (10 MAY 54)



VIEW OF SCRAP AND BOMB, M47, H CONTAMINATED STORED IN TOXIC GAS YARD. (10 MAY 54)



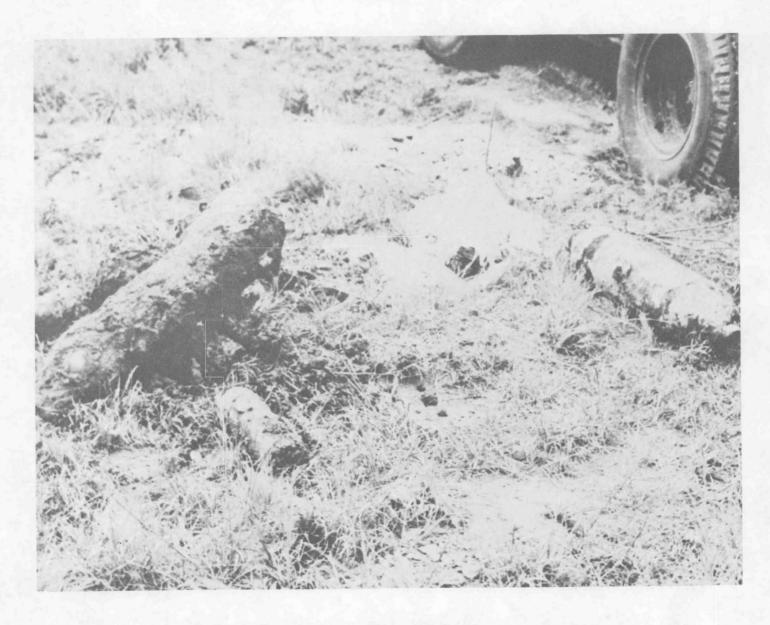
OVERALL VIEW OF BURIED MUSTARD FILLED MUNITIONS, FACING SOUTHWEST. (10 MAY 54)



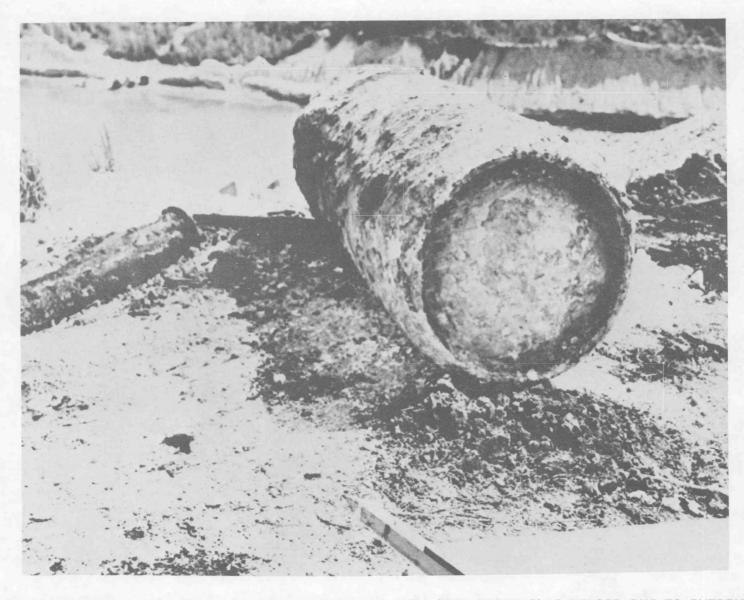
A PIT THAT HAS HAD INCENDIARY MATERIAL PLACED ON BOTTOM, THE 4.2 SHELLS ON TOP OF MATERIAL IN BURNING PIT AREA. (20 APRIL 55)



4.2 SHELLS, M70 BOMBS, M47 BOMBS AND OTHER SCRAP DUG FROM MUSTARD PIT. (28 APRIL 55)



LEAKING M70 LEWISITE FILLED BOMBS. (28 APRIL 55)



END VIEW OF TON CONTAINER, "D" TYPE. ONE OF THE ENDS (END SHOWING) IS BULGED DUE TO EXTREME PRESSURE AT ONE TIME. (3 MAY 55)



M70 BOMB BODIES AFTER BEING BURNT IN PITS. (23 JUNE 55)



MUSTARD FILLING BUILDING, PBA, JUNE 1977

APPENDIX C

STANDING OPERATING PROCEDURE NUMBER 74-15

OPERATION OF SOUTH AREA WATER TREATMENT PLANT

PINE BLUFF ARSENAL

A copy of this report can be obtained from:

Department of the Army Headquarters, Pine Bluff Arsenal Pine Bluff, Arkansas 71601 APPENDIX D

BORING LOGS

PINE BLUFF ARSENAL

BORING LOGS WATER QUALITY MONITORING WELLS PINE BLUFF ARSENAL

Test Numbers 1 and 2

NOTE: Wells 1 and 2 were drilled to 135 and 100 feet respectively without evidence of water. They were abandoned as dry holes.

Test Number 3, 9 May 1967

Elev - From	Inches To	Description	
0	27	Fill and silty clay	
27	46	White clay	
47	79	Blue clay	•
79	84	Brown clay	
84	91	Fine sandy clay	
91	178	Clay	•
178	200	Sandy clay	
200	216	Clay	
216	217	Rock	
217	303	Clay	
303	304	Rock	
304	321	Clay	
321	322	Rock	
322	336	Shale	•
336	337	Rock	•
337	425	Shale	
425	447	Sandy shale	•
447	457	Shale	
457	464	Sandy shale	
464	570	Shale	
570	640	Fine sandy shale	
640	685	Fine sand	
685	000	Break in formation	

Test Number 4, 24 May 1967

lev - From	Inches To	Description	
0	23	White sandy clay	}••
23	43	Red sandy clay	
43 51	51	Fine silty sand	
51	60	Fine sand	
60	68	Coarse sand	•
68	73	Fine sand	•
73	81	Coarse sand	

Test Number 5, 7 April 1967

lev - From	Inches To	Description	
. 0	13	Soil and clay	•
13	23	Fine sand	
23	55	Sandy clay	
55	63	Fine sand	•
63	80	Coarse sand	
80		Blue clay	

Test Number 6, 6 April 1967

lev - 1 From	То	Description	and the second second
0	13	Fill and clay	,
13	20	Fine sand	.
20	39	Medium sand	
20 39	51	Muddy sand and clay	
51	62	Fine sand	
62	76	Medium sand	
76		Blue clay	

Test Number 7, 10 April 1967

Elev - :	Inches				
From	To	Description	· · · · · · · · · · · · · · · · · · ·	1 1 1	·.
0	16	Soil and clay	· ·		
16	32	Fine sandy clay	-		
32	65	Fine sand	•		
65	87	Coarse sand		•	

Test Number 8, 11 April 1967

Elev - From	Inches To	Description	
0 37	37 42	Soil and sandy clay	
42	68	Coarse sand	

Test Number 9, 17 April 1967

lev - 1 From	То	Description	
. 0	14	Soil and clay	
14	22	White sand	
22	38	Red sandy clay	
38	51	Medium sand	
51	62	Coarse sand	

Test Number 10, 18 April 1967

Elev - 1 From	Inches To	Description	· .
0	33	Sandy clay	
33	48	Medium sand	
48	64	Coarse sand	

Test Number 11, 18 April 1967

lev - From	То	Description	
0	10	Clay	
10	18	White sand	•
18	31	Sandy clay	•
31	48	Fine sand	
48	64	Coarse sand	4

Test Number 12, 19 April 1967

From	Inches To	Description	
0	18	Clay	
18	21	White sandy clay	
21	35	Clay	
35	51	Fine sand	
51	66	Coarse sand	

Test Number 13, 20 April 1967

Elev - From	Inches To	Description	1.
0 59	59 76	Clay Coarse sand	· · · ·

Test Number 14, 20 April 1967

Elev - From	Inches To	Description	
0	10	Clay	
10	13	Red sand	
13	33	Clay	
33	55	Red sand	•
55	70	Coarse sand	

Test Number 15, 21 April 1967

lev - : From	То	Description
0	14	Clay
14	18	White sand
18	33	Sandy clay
33	51	Red sand
51	71	Coarse sand

Test Number 16, 24 April 1967

0.75	lev - In From	ches To		Des	cription		-
**	0 7	7 17	Clay Sand	y clay*.			-
ing No.	17 23 35	23 35 55	Fine Sand	sand y clay sand	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1
•	55	72		se sand			

Test Number 17, 28 April 1967

Elev - Inches From To	Description	
0 42	Clay	
60 77	Fine sand Coarse sand	

Deep Well Number 2

Elev From	- Feet To	Description
0	10	Hard pan
10	30	Sand
30	50	Clay
50	94	Coarse sand
94	100	Clay
100	175	Sandy shale
175	205	Tough shale
205	225	Sandy shale
225	248	Tough shale
248	258 205	Sandy shale
258	285 286	Fine sand, streaks of shale
285 286	292	Rock Sandy shale
292	301	Shale
301	316	Sandy shale
316	348	Tough shale
348	352	Hard spot
352	362	Sandy shale
362	366	Tough shale
366	367	Rock
367	370	Tough shale
370	372	Rock
372		Shale and boulders
382	383	Rock
383	390	Shale
390	440	Tough shale
440	479	Sandy shale
479	485 536	Shale Sandy shale
485 536	536 554	Sandy shale Tough shale
554	564	Fine sand
564	565	Rock
565	57 4	Sandy shale
574	576	Hard spot
576	597	Shale
597	602	Fine sand
602	603	Rock
603	628	Tough shale
628	647	Fine sand
647	755	Tough shale
755	756	Rock
756	783	Sand with streak of sand
783	807	Fine sand

Deep Well Number 2 (continued)

Elev From	- Feet To	Description
807	814	Tough shale
814	827	Fine sand, streaks of shale
827	837	Fine hard sand
837	841	Tough shale
841	855	Sandy shale
855	857	Rock
857	861	Shale
861	863	Shale and boulders
863	895	Sandy shale
895	905	Tough gumbo
905	915	Fine sand, salt and pepper
915	937	Fine sand, salt and pepper
937	981	Fine salt and pepper sand
981	998	Medium salt and pepper sand
998	1001	Break
1001	1004	Sand
1004	1007	Break, lignite
1007	1026	Medium salt and pepper sand
1026	1028	Break, lignite
1028	1040	Medium salt and pepper sand
1040	1062	Tough shale
1062	1065	Fine sand
1065	1070	Shale
1070	1076	Fine sand
1076	1084	Tough shale
1084	1087	Sandy shale
1087	1104	Fine sand
1104	1136	Coarse, deep, salt and pepper sand
1136 1144	1144 1170	Tough gumbo
1144	1170	Real fine, hard packed sand

BORING LOGS DEEP WELLS PINE BLUFF ARSENAL

Deep Well Number 1

Elev	- Feet	
From	То	Description
0	7 ·	Soi1
7	95	Sand
95	140	Shale
140	185	Sandy shale
185	255	Sand
255	272	Hard sandy shale
272	273	Rock
273	350	Sandy shale
350	378	Shale (with boulders)
378	428	Sandy shale
428	450	Shale
450	459	Shale with streaks of sand
459	461	Rock
461	487	Tough shale
487	570	Sandy shale
570	588	Tough shale
588	596	Sanď
596	618	Shale with streaks of sand
618	675	Shale
675	737	Tough shale
737 ·	743	Sand
743	761	Shale
761	765	Fine sand
765	767	Tough shale
767	773	Fine sand
773	779	Tough shale
779	799	Fine sand
799	804	Hard shale
804	814	Fine sand
814	817	Hard shale
817	847	Sandy shale with streaks of sand
847	848	Break
848	870	Shale with streaks of sand
870	890	Fine sand with hard streaks
890	897	Tough gumbo
897	939	Fine hard sand
939	980	Fine hard sand
980	1070	Hard salt and pepper sand
1070		Sand

Deep Well Number 3

Elev - From	Feet To		Description	:	
- 0	2		Soi1		
2	26		Sandy soil	·	
26	38		Coarse brown sand		
38	74		Fine red sand		
74	94		Coarse red sand		
94	198		Fine muddy sand		
198	226		Shale		
226	234		Fine sand		
234	258		Sandy shale		
258	276		Fine muddy sand		
276	277	•	Boulders		
277	286		Fine muddy sand		
286	287	•	Boulders	•	
287	292		Fine hard sand		•
292	323		Soft gummy shale		
323	324		Hard rock		
324	349		Shale		
349	363	•	Shale with hard streaks		
363	365		Rock		•
365	370		Shale		
370	428		Sandy shale		-
428	438		Shale with streak of sand]	
438	461		Fine sand		
461	466		Shale with streak of sand	1	
466	516		Soft shale	,	
516	530		Fine sand		
530	539		Sandy shale		•
539	557		Fine sand		
557	558		Rock		
558	593		Sand and shale		
593	594		Rock		
594	616		Sand and shale		
616	638		Fine sand		
638	673		Shale		
673	675		Rock		
675	719		Tough shale		
719	720		Rock		
720	733		Tough shale		
733	734		Rock		
734	764		Tough shale		
764	785		Fine salt and pepper sand	ı	

Deep Well Number 3 (continued)

From :	- Feet To	Description
785	813	Coarse, deep salt and pepper sand
813	817	Break, sandy shale
817	818	Boulders
818	825	Fine sand
825	829	Sand
829	832	Break
832	991	Good salt and pepper sand
991	993	Break, shale
993	1008	Good sand
1008	.1023	Sand, mixed about half and half lignite
1023	1047	Shale, lignite, streak sand

Deep Well Number 14

Elev -	- Feet	
From	To	Description
0	25	Sandy clay
25	31	Soap stone
31	65	Real fine sand
65	160	Sandy shale
160	161	Rock
161	209	Shale
209	210	Rock
210	223	Shale
223	223 224	
	255 255	Rock Shale
224	256 256	Rock
255 256		
256 321	321 350	Sandy shale
360	360 445	Shale
		Sandy shale
445	446 460	Rock
446	460 485	Sandy shale
460 465	485	Gumbo
485	613	Shale
613	712	Medium coarse sand
712	716	Sandy shale
716	751 754	Real fine hard packed sand
751	754	Break
754	806	Medium sand
806	835	Gumbo and boulders
835	836	Rock
836	855	Gumbo
855	883	Sandy shale
883	953	Medium coarse sand
953	989	Shale and gumbo

Deep Well Number 15

Elev	- Feet	
From	<u>To</u>	Description
0	26	Sandy clay
26	100	Soft shale
100	172	Sandy shale
172	173	Rock
173	220	Shale
220	252	Gumbo
252	253	Rock A Service Control of the Contro
253	260	Sandy-shale
260	261	Rock
261	271	Shale
271	272	Rock
272	315	Shale
315	360	Sandy shale
360	430	Shale
430	467	Sandy shale
467	468	Rock
468	604	Hard shale
604	605	Rock
605	626	Shale
626	627	Rock
627	688	Gumbo
688	692	Sand
692	694	Break
694	722	Hard salt and pepper sand
722	735	Real fine hard sand
735	767	Hard medium salt and pepper sand
767	769	Break William Street St
769	795	Hard medium salt and pepper sand
795	822	Gumbo
822	824	Boulders
824	838	Shale The State of
838 _.	852	Real fine sand
852	854	Break Break
854	876	Sand streaked with shale
876	1016	Good medium salt and pepper sand
1016	· · · · · · · · · · · · · · · · · · ·	Gumbo
	* 1	

Deep Well Number 16

Elev From	- Feet To			Description	on A		
0	60		Sandy cla	ív			30
60	68		Real fine	.y Sand			Ä,
68 ~	170		Gumbo		· · · · · · · · · · · · · · · · · · ·	<i>: .</i>	1000
170	171		Rock		10 (1) 10 (1) 10 (1)		
171	2.48		Gumbo		• • • • •	•	
248	249	3	Rock		⊆ 3	. • '	
249	255		Gumbo	. V 💸 7		-	
255	258		Boulders				
258	274		Gumbo		- 10 m	1-1	
274	275		Rock				
275	287		Shale `	3.1	∘ 32· • · ·	• • • •	
287	288		Rock		1 T 2 2 2) K	
288	376		Shale	20, 5 %			•
376	400		Fine sand				
400	444	- 1	Shale			1-1	. '
444	445		Rock			, V, ,	. :
445	498		Shale		· Section 1		
498	545		Sandy sha	le É	il a		
545	608		Gumbo	•	٠, ٠	. • •	
608	609		Rock		-		•
609	695		Gumbo		•	•	
695	710		Sandy sha	le.			
710	750		ine sand				
750	753	- <u> </u>	Shale		·.		
753	794	F	ine hard	sand	- :- :		
794	855		andy sha				
855	869	F	ine sand			· ·	
869	885	S	andy sha	le	•	4	
885	987		ine hard			5	
987	989		reak				
989	1048			and pepper	sand	•	
Stopped	in Gumbo					ogy A Children	

Deep Well Number 17

Elev -	Feet	
From	То	Description
0	8	Sandy clay
8	30	Clay
30	33	Sand
33	68	Clay
68	73	Sand
73	163	Clay
163	168	Fine sand
168	189	Shale
189	200	Shale and boulders
200	242	Shale
242	243	Rock
243	271	Shale
271	294	Shale and boulders
294	301	Shale
301	312	Rock
312	410	Shale
410	423	Medium sand
423	431	Shale
431	445	Sand streaked with shale
445	448	Shale
448	450	Rock
450	469	Hard shale
469	470	Rock
470	587	Hard shale
587	600	Sandy shale
600	617	Shale streaked with sand
617	663	Fine sand streaked with shale
663	704	Shale
704	724	Fine hard sand
724	757	Hard packed medium sand
757	765	Break [*]
765	835	Hard medium packed sand
835	867	Shale
867	936	Real fine, hard sand
936	960	Sandy shale

Deep Well Number 18

Elev From	- Feet To	Description
0 25	25 31	Sandy clay Hard clay
31	41	Medium sand
41	90	Sandy shale
90	140	Gumbo
140	215	Sandy shale
215	246	Gumbo
246	247	Rock
247	273	Gumbo
273	274	Rock
274	278	Gumbo
278	279	Rock
279	302	Shale
302	303	Rock
303	390	Shale
390	391	Rock
391	448	Shale
448	449	Rock
449	525	Sandy shale
525	586	Hard shale
586	587	Rock
587	669	Hard shale
669	696	Sandy shale
696	779	Medium sand
779	785	Break Modium cond
785	813	Medium sand
813	814	Break Medium sand
814 832	832 872	Shale
032	0/2	Silate

APPENDIX E

FAUNA AND FLORA

BIOTA OF PINE BLUFF ARSENAL AREA

FAUNA

Mamma 1s

Common Name

Carolina short-tailed shrew

Coyote

Mississippi Valley red wolf

Beaver

Least shrew

Nine banded armadillo

Virginia opossum

Oklahoma pocket gopher

Flying squirrel

Northern red bat

Bobcat

Striped skunk

Pine vole

House mouse

Missouri weasel

Large brown mink

Whitetail deer

Muskrat

Texas rice rat

Cotton mouse

Southern white-footed mouse

Scientific Name

Blarina brevicauda carolinensis

Canis latrans

Canis niger gregori

Castor canadensis

Cryptotis parva

Dasypus Novembinctus

Didelphis marsupialis virginiana

Geomys bursarius dutcheri

Glaucomys volans

Lasiurus borealis borealis

Lynx rufus

Mephitis mephitis

Microtus pinetorum

Mus musculus

Mustela frenata primulina

Mustela vison mink

Odocoileus virginianus

Ondatra zibethicus

Oryzomys palustris texensis

Peromyscus gossypinus megacephalus

Peromyscus leucopus leucopus

Mammals (continued)

Common Name

Deer mouse

Golden mouse

Raccoon

Norway rat

Harvest mouse

Arkansas mole

Gray squirrel

Fox squirrel

Hispid cotton rat

Eastern spotted skunk

Swamp rabbit

Cottontail rabbit

Wisconsin gray fox

Red fox

Scientific Name

Peromyscus maniculatus

Peromyscus nuttalli flammeus

Procyon lotor

Rattus norvegicus

Reithroden tormys fulvescens

Scalopus aquaticus pulcher

Sciurus carolinensis carolinensis

Sciurus niger rufiventer

Sigmodon hispidus hispidus

Spilogale putorius

Sylvilagus aquaticus

Sylvilagus floridanus alacer

Urocyon cinereoargenteus ocythous

Vulpes fulva

Birds

Cooper's hawk

Sharp-shinned hawk

Spotted sandpiper

Red wing

Wood duck

Pintail

Blue-winged teal

Mallard

Accipiter cooperi

Accipiter striatus

Actitis macularia

Agelaius phoeniceus

Anas acuta

Anas discors

Anas platyrhynchos

Common Name

Black duck

Water pipit

Ruby-throated hummingbird

Great blue heron

Lesser scaup

Ring-necked duck

Cedar waxwing

Canada goose

Great horned owl

Red-tailed hawk

Red-shouldered hawk

Broad-winged hawk

Wilson's snipe

Chuck-Will's widow

Whip-Poor-Will

Purple finch

American egret

Turkey vulture

Red-bellied woodpecker

Brown creeper

Chimney swift

Blue goose

Snow goose

Black tern

Scientific Name

Anas rubripes

Anthus spinoletta

Archilocus colubris

Ardea herodias

Aythya affinis

Aythya collaris

Bombycilla cedrorum

Branta canadensis

Bubo virginianus

Buteo jamaicensis

Buteo lineatus

Buteo platypterus

Capella gallinago

Caprimulgus carolinensis

Caprimulgus vociferus

Carpodacus purpureus

Casmerodius albus

Cathartes aura

Centurus carolinus

Certhia familiaris

Chaetura pelagica

Chen caerulescens

Chen hyperborea

Chlidonias niger

Common Name

Scientific Name

Nighthawk

Marsh hawk

Yellow-billed cuckoo

Flicker

Bob-white quail

Eastern wood pewee

Black vulture

Common crow

Fish crow

Blue jay

Red-cockaded woodpecker

Downy woodpecker

Hairy woodpecker

Bay-breasted warbler

Cerulean warbler

Yellow-rumped warbler

Prairie warbler

Yellow-throated warbler

Blackburnian warbler

Magnolia warbler

Chestnut-sided warbler

Yellow warbler

Pine warbler

Black-poll warbler

Chordeiles minor

Circus cyaneus

Coccyzus americanus

Colaptes auratus

Colinus virginianus

Contopus virens

Coragyps atratus

Corvus brachyrhynchos

Corvus ossifragus

Cyanoeitta cristata

Dendrocopes borealis

Dendrocopes pubescens

Dendrocopes villosus

Dendroica castanea

Dendroica cerulea

Dendroica coronata

Dendroica discolor

Dendroica dominioa

Dendroica fusca

Dendroica magnolia

Dendroica pennsylvanica

Dendroica petechia

Dendroica pinus

Dendroica striata

Common Name

Black-throated green warbler

Pileated woodpecker

Catbird

Least flycatcher

Acadian flycatcher

Rusty blackbird

Duck hawk

Kestre?

Little blue heron

Coot

Yellow-throat

Blue grosbeak

Bald eagle

Worm-eating warbler

Caspian tern

Veery

Hermit thrush

Gray-cheeked thrush

Wood thrush

Olive-backed thrush

Yellow-breasted chat

Northern oriole

Orchard oriole

Slate-colored junco

Scientific Name

Dendroica virens

Dryocopus pileatus

Dumetella carolinensis

Empidonax minimum

Empidonax virescens

Euphagus carolinus

Falco peregrinus

Falco sparverius

Florida caerulea

Fulica americana

Geothlypis trichas

Guiraca caerulea

Haliacetus leucocephalus

Helmitheros vermivorus

Hydroprogne caspia

Hylocichla fuscescens

Hylocichla guttata

Hylocichla minima

Hylocichla mustelina

Hylocichla ustulata

Icteria virens

Icturus glabula

Icturus spurius

Junco hyemalis

Common Name

Loggerhead shrike

Ring-billed gull

Belted kingfisher

Red-headed woodpecker

Turkey

Swamp sparrow

Lincoln's sparrow

Song sparrow

Mockingbird

Black and white warbler

Cowbird, abundant

Crested flycatcher

Kentucky warbler

Screech owl

0sprey

Parula warbler

Tufted titmouse

Carolina chickadee

English sparrow

Savannah sparrow

Fox sparrow

Leconte's sparrow

Henslow's sparrow

Indigo bunting

Scientific Name

Lanius ludovicianus

Larus delawarensis

Megaceryle alcyon

Melanerpes erythrocephalus

Meleagris gallopavo

Melospiza georgiana

Melospiza lincolnii

Melospiza melodia

Mimus polyglottos

Mniotilta veria

Molothrus ater

Mylarchus crinitus

Oporornis formosus

Otus asio

Pandion haliaetus

Parula americana

Parus bicolor

Parus carolinensis

Passer domesticus

Passerculus sandwichensis

Passerella iliaca

Passerherbulus caudactus

Passerherbulus henslowi

Passerhirina cyanea

Common Name

White pelican

Double-crested carmorant

Rose-breasted grosbeak

Woodcock

Red-eyed towhee

Summer tanager

Pied-billed grebe

Blue-gray gnatcatcher

Purple martin

Prothonotary warbler

Common grackle

Ruby-crowned kinglet

Golden-crowned kinglet

Cardinal

Eastern phoebe

Ovenbird

Louisiana water-thrush

American redstart

Eastern bluebird

White-breasted nuthatch

Yellow-bellied sapsucker

Pine siskin

Goldfinch

Chipping sparrow

Scientific Name

Pelecanus erythrorhynchos

Phalacrocorax auritus

Pheuticus Iudovicianus

Philohela minor

Pipilo erythrophthalmus

Piranga rubra

Polilymbus podiceps

Polioptila caerulea

Progne subis

Protonotaria citrea

Quiscalus quiscula

Regulus calendula

Regulus satrapa

Richmondena cardinalis

Sayornis phoebe

Seiurus aurocapillus

Seiurus motacilla

Setophaga ruticilla

Sialia sialis

Sitta corolinensis

Sphyrapicus varius

Spinus pinus,

Spinus tristis

Spizella passerina

Common Name

Field sparrow, common

Rough-winged swallow

Barred owl

Eastern meadowlark

Starling

Bewick's wren

Carolina wren

Brown thrasher

Solitary sandpiper

Winter wren

Robin

Eastern kingbird

Orange-crowned warbler

Golden-winged warbler

Tennessee warbler

Nashville warbler

Yellow-throated vireo

Warbling vireo

White-eyed vireo

Red-eyed vireo

Solitary vireo

Canada warbler

Hooded warbler

Wilson's warbler

Scientific Name

Spizella pusilla

Stelgidopteryx ruficollis

Strix varia

Sturnella magna

Sturnus vulgaris

Thyromanes bewickii

Thyrothorus lucovicianus

Toxostoma rufum

Tringo solitaria

Toglodytes troglodytes

Turdus migratorius

Tyrannus tyrannus

Vermivora celata

Vermivora chrysoptera

Vermivora peregrina

Vermivora ruficapilla

Vireo flavifrons

Vireo gilvus

Vireo griseus

Vireo olivaceus

Vireo solitarius

Wilsonia canadensis

Wilsonia citrina

Wilsonia pusilla

Common Name

Mourning dove

White-throated sparrow

White-crowned sparrow

Scientific Name

Zenaidura macroura

Zonotrichia albicollis

Zonotrichia leocophrys

Fish

(1) Species found in ponds and lakes on the Arsenal

Drum Aplodinotus grunniens

Warmouth Chaenobryttus gulosus

Carp Cyprinus carpio

Chain pickerel Esox niger

Yellow bullhead Ictalurus natalis

Channel catfish Ictalurus punctatus

Shortnose gar Lepisosteus platostomus

Yellowbelly sunfish Lepomis auritus

Green sunfish Lepomis cyanellus

Pumpkinseed sunfish Lepomis gibbosus

Bluegill sunfish Lepomis macrochirus

Longear sunfish Lepomis megalotis

Redear sunfish Leopmis microlophus

Largemouth bass Micropterus salmoides

Paddlefish Polydon spathula

Fish (continued)

(2) Species found only in the Arkansas River, bordering the Arsenal, and in Yellow Lake, which is occasionally completely inundated by the Arkansas River floodwaters

Common Name

Scientific Name

Gizzard shad

Blue catfish

Black bullhead

Brown bullhead

Smallmouth buffalo

Bigmouth buffalo

Black buffalo

Alligator gar

Spotted bass

White crappie

Black crappie

Flathead catfish

Shovelnose sturgeon

Dorosoma cepedianum

Ictalurus furcatus

Ictalurus melas

Ictalurus nebulosus

Ictiobus bubalus

Ictiobus cyprinellus

Ictiobus niger

Lepisosteus spatula

Micropterus punctulatus

Pomoxis annularis

Pomoxis nigromaculatus

Pylodictis olivaris

Schaphirhynchus platorynchus

Reptiles and Amphibians

Snakes

Southern copperhead

•

Cottonmouth

Wormsnake

Scarlet snake

Black racer

Timber rattlesnake

Agkistrodon contortrix contortrix

Agkistrodon piscivorus

Carphophis amoenus

Cemophora coccinea

Colubar contrictor

Crotalus horridus

Snakes (continued)

Common Name

Southern ring-necked snake

Black rat snake

Mud snake

Rough earthsnake

Smooth earthsnake

Eastern hog-nosed snake

Priarie kingsnake

Speckled kingsnake

Eastern coachwhip .

Red-bellied watersnake

Yellow-bellied watersnake

Diamond-backed watersnake

Northern watersnake

Rough greensnake

Pigmy rattlesnake

Northern brownsnake

Red-bellied snake

Eastern gartersnake

Eastern ribbonsnake

Scientific Name

Diadophis punctatus punctatus

Elaphe obsoleta obsoleta

Farancia abacura

Haldea striatula

Haldea valeria

Heterodon platyrhinos

Lampropeltis calligaster

Lampropeltis getulus holbrooki

Masticophis flagellum

Natrix erythrogaster erythrogaster

Natrix erythrogaster flavigaster

Natrix rhombifera rhombifera rhombifera

Natrix sipedon sipedon

Opheodrys aestivus

Sistrurns miliarius

Storeria dekayi

Storeria occipitomaculata

Thamnophis sirtailis sirtalis

Thamnophis sauritus

Turtles

Chelydra serpentina

Chrysemys picta dorsalis

Graptemys geographica

Graptemys pseudogeographica

False map turtle

Map turtle

Snapping turtle

Southern painted turtle

Turtles (continued)

Common Name

Scientific Name

Mudturtle

Kinosternon subrubrum

Alligator snapping turtle

Macroclemys temmincki

Cooter

Pseudemys floridana concinna

Red-eared turtle

Pseudemys scripta elegans

Stinkpot

Sternotherus odoratus

Box turtle

Terrapene carolina

Smooth softshell turtle

Trionyx muticus

Lizards

Six-lined racerunner

Cnemidophorus sexlineatus

Five-line skink

Eumeces fasiatus

Broad-headed skink

Eumeces laticeps

Ground skink

Lygosoma laterale

Slender glass lizard

Ophisaurus attenuatus

Eastern fence lizard

Sceloporus undulatus

Salamanders

Spotted salamander

Ambystoma maculatum

Marbled salamander

Ambystoma opacum

Small-mouthed salamander

Ambystoma texanum

Dusky salamander

Desmognathus fuscus

Central newt

Diemictylus viridescens

Mudpuppy

Necturus maculosus

Slimy salamander

Plethodon glutinosus

Salamanders (continued)

Common Name

Scientific Name

Lesser siren

Siren intermedia

Toads and Frogs

American toad

Dwarf American toad

Woodhouse's toad

Green tree frog

Spring peeper

Gray tree frog

Bullfrog

Pickerel frog

Leopard frog

Bufo terrestris

Bufo americanus charlesmithi

Bufo woodhouset

Hyla cinerea

Hyla crucifer

Hyla versicolor

Rana catesbeiana

Rana palustris

Rana pipiens

FAUNA (continued)

Invertebrate taxa collected in streams on the Arsenal from July 1973 through November 1974

Arthropoda

Insecta

Coleoptera (beetles)

Dytiscidae (predaceous diving beetles)

Hydroporus sp.

Diptera (true flies)

Ceratopogonidae (biting midges)

Palpomyia spp.

Culicidae: chaoborinae (phantom midges)

Chaoborus punctipennis

Chironomidae (midges)

Anatopynia sp. 1 (nr)*

<u>Calopsectra</u> sp.

Chironomus modestus

Chironomus riparius (nr)

Clinotanypus thoracicus (nr)

<u>Glyptotendipes</u> <u>senilis</u>

Hydrobaenus sp. 2

Pentaneura carnea (nr)

Pentaneura monilis

^{*(}nr) indicates that identification is considered to be near this species; however, the description of the species itself may include several taxa.

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Insecta (continued)
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Chironomidae (midges) (continued)

Polypedilum halterale (nr)

Polypedilum illinoense

Procladius adumbratus (nr)

Procladius culiciformis

Psectrocladius flavus

Tanypus neopunctipennis

Simuliidae (black flies)

Simulium vittatum

Tipulidae (crane flies)

Chrysops sp.

Tipula spp.

Ephemeroptera (mayflies)

Baetidae

Caenis spp.

Neocloeon alamance

Ephemeridae

Hexagenia limbata

Heptageniidae

Stenonema tripunctatum

Hemiptera (true bugs)

Belostomatidae (giant water bugs)

Belastoma sp.

Odonata

Anisoptera (dragonflies)

Insecta (continued)

Odonata (continued)

Calopterygidae

Calopteryx maculata

. Cordulegasteridae

Cordulegaster sp.

Libellulidae

Celithemis eponina

Erythemis simplica

Erythemis simplicollis

Erythrodiplax minuscula

Libellula spp.

Libellula luctuosa

<u>Libellula</u> vibrans

Macromia magnifica

Pachydiplax longipennis

Pantala flavescens

Pantala hymenea

<u>Plathemis</u> sp.

<u>Plathemis lydia</u>

Perithemis tenera

Tetragoneuria cynosura

Coenagrionidae (damselflies)

<u>Anomalagron hastatum</u>

Argia spp.

Argia apicalis

Insecta (continued)

Coenagrionidae (damselflies) (continued)

Argia fumipennis

Argia moesta

Coenagrion spp.

Enallagma basidens

Enallagma civile

Enallagma cyathigerum

Enallagma divagans

Enallagma signatum

Ischnura ramburii

Plecoptera (stoneflies)

Perlidae

Perlesta spp.

Nemouridae

Nemoura spp.

Trichoptera (caddisflies)

Hydropsychidae

Potamyia flava

Lepidoptera (aquatic moths)

Pyralidae unknown

Crustacea

Isopoda (aquatic sow bugs)

Asellidae

Asellus obtusus

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Crustacea (continued)
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Asellidae (continued)

Asellus dentadactylus

Amphipoda (side swimmers, scuds)

Gammari dae

Synurella bifurca

Hyalellidae

Hyalella azteca

Decapoda

Palaemonidae (grass shrimp)

Palaemonetes kadiakensis

Astacidae (crayfish)

Oronectes palmeri longimanus

Procambarus ouachitae

Procambarus clarkii

Procambarus immatures

Annelida

Oligochaeta

Tubificidae (sludge worms)

Limnodrilus hoffmeisteri

Stylaria fossularis

Hirudinea (leeches)

 ${\tt Glossiphonidae}$

Placobdella parasitica

Piscicol idae

Piscicola sp.

Mollusca

Pelecypoda (clams)

Sphaeriidae (finger nail clams)

Sphaerium transversum

Gastropoda (snails)

Physidae (pouch snails)

Physa spp.

Lymnaeidae (pond snails)

Limnaea spp.

Ancylidae (limpets)

Ferrissa sp.

Planorbidae (orb snails)

Gyraulus sp.

Platyhelminthes

Turbellaria (flat worms)

Planariidae (planaria)

Dugesia tigrina

FLORA

Trees.

Common Name	Scientific Name
Box elder	Acer negundo
Red maple	Acer rubrum
Silver maple	Acer saccharinum
River birch	Betula nigra
Hophornbeam	Carpinus caroliniana
Pecan	Carya illinoensis
Black hickory	Carya texana arkansas
Mokernut hickory	Carya tomentesa
Chinquapin	Castanea pumila
Hackberry	Celtis laevigata
Dogwood	Cornus florida
Persimmon	Diospyros virginiana
White ash	Fraxinus americana
Green ash	Fraxinus pennsylvanica
American holly	Ilex opaca
Sweet gum	Liquidambar, stryaciflua
Black gum	Nyssa sylvatica
Shortleaf pine	Pinus echinata
Loblolly pine	Pinus taeda
Sycamore	Platanus occidentalis
Cottonwood	Populus deltoides
White oak	Ouercus alba

Red oak

Quercus falcata

Trees (continued)

Common Name

Scientific Name

Water oak

Willow oak

Post oak

Black willow

Quercus nigra

Quercus phellos

Quercus stellata

Salix nigra

Shrubs

Buckeye.

Hawthorn

Dwarf huckleberry.

Eastern redcedar

Honeysuck le

Wildplum

Shining sumac

Poison ivy

Blackberry

Dewberry

Greenbrier

Winter huckleberry

Grape

Aesculus discolor

Crataegus viridis

Gaylussacia dumosa

Juniperus virginiana

Lonicera spp.

Prunus angustifola

Rhus copallina

Rhus radicans

Rubus spp.

Rubus spp.

Smilax spp.

Vaccinium aboreom

Vitis spp.

Grasses

Fescue grass

Smooth brome

Bermuda grass

Bromus catharticus

Bromus inermis

Cynodon dactylon

Grasses (continued)

Common Name

Orchard grass

Barnyard grass

Rye grass

Blue panic

Torpedo grass

Dallis grass

Field pasnalum

Ribbed paspalum

Vasey grass

Yellow bristlegrass

Johnson grass

Sorghum

Scientific Name

Dactylis glomerata

Exhinochloa crusgalli

Lolium multiflorum

Panicum antodotale

Panicum repens

Paspalum malacophyllum

Paspalum laeve

Paspalum malacophyllum

Paspalum urvillei

Setaria glauca

Sorghum halepense

Sorghum vulgare

Legumes

Singletary pea

Sericea lespedeza

Korean lespedeza

Kobe lespedeza

Spotted bur-clover

Little bur-clover

Alfalfa

Alsika clover

Crimson clover

Ball clover

Lathyrus hirsutus

Lespedza cuneata

Lespedeza stipulacea

Lespedeza striata

Medicage arabica

Medicago minima

Medicago sativa

Trifolium hybridum

Trifolium incarnatum

Trifolium nigrescens

Legumes (continued)

Common Name

Scientific Name

Red clover

White clover

Voollypod vetch

Hungarian vetch

Common vetch

Hairy vetch

Trifolium pratense

Trifolium repens

Vicia dasycarpa

Vicia pannonica

Vicia sativa

Vicia villosa

Weeds

Foxtail

Ragweed

Partridgepea

Tickclover

Pokeberry

Smartweed

Sogo pondweed

Dandelion

Alopecurus pratensis

Ambrosia psilostachya

Chamaecrista fascieulata

Desmodium sessilifolium

Phytolacca americana

Polygonum pensylvanicum

Potamogeton pectinatus

Taraxacum officinale

APPENDIX F

DRAFT EDGEWOOD ARSENAL TECHNICAL REPORT

TERRESTRIAL ECOLOGICAL SURVEYS AT PINE BLUFF ARSENAL

FEBRUARY 1977

SECURITY CLASSIFICATION OF THIS PAGE (Then Date Entered)

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Plants Amphibians Mammals Pine Bluff Arsenal	al committee are healthy

EDGEWOOD ARSENAL TECHNICAL REPORT TERRESTRIAL ECOLOGICAL SURVEYS AT PINE BLUFF ARSENAL PINE BLUFF, ARKANSAS

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February 1977

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DISPOSITION

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PREFACE

The work described in this report was authorized under task 2, subproject 3, PAA 57X4114, Development of Methods to Minimize Environmental Contamination, Ecological Surveys of Environmental Conditions at USAMC installations. This is a three-phase program: phase 1, Initial Site Visit, completed November 1972; phase II, Preliminary Environmental Survey, completed January 1973; and phase III, Ecological Surveys, initiated in January 1973. Phase III is divided into three separate aquatic surveys:

- (1) Pine Bluff Arsenal streams, initiated January 1973, completed July 1974;
- (2) Yellow Lake, initiated March 1974, completed January 1976, and (3) Production Area Drainages, initiated January 1975.

The data presented here were gathered during two terrestrial ecological surveys of phase III conducted in May and September, 1973.

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I. INTRODUCTION

Pine Bluff Arsenal (PBA), Arkansas, was constructed in 1941 for the manufacture, loading, and assembly of magnesium and thermite types of incendiary bombs. The initial mission was quickly expanded to include the manufacture of war gases and the filling of chemical bombs, incendiary smoke munitions, and other munitions with chemicals such as chlorine, mustard, and lewisite. Development of facilities for biological warfare operations began in 1953. Through the 1950's the Diamond Alkali and Chemical Company used facilities at PBA to make chlorine for use by Niagra Chemical Company (another contractor) which made DDT, mainthien, parathion, and chorobenzenes. Biological warfare activities were discontinued in 1969.

Ecological surveys were initiated to establish past and present effects of installation activities on the environment, as a baseline against which to compare the impact of a centralized pollution abatement facility scheduled for completion in FY 79. Little information was found on the terrestrial fauna and flora of the site during the preliminary environmental survey. Therefore these surveys also were designed to expand and document a baseline of ecological conditions at PBA.

Problem areas were discovered and reported elsewhere. This report concerns itself mainly with the terrestrial survey data and is not intended to be comprehensive; rather the data are published to serve as a baseline for environmental assessments and for future ecological comparisons.

A. Survey Sectors

Maps were used for each of the surveys which divide the installation into 23 sectors, the boundaries of which were distinguishable on the ground as roadways or prominent stream drainages. (Fig. 1). An attempt was made not to divide areas comprising major installation activities, (such as industrial or administrative areas) but rather, to examine these areas as individual sectors. (Table 1)

Figure 1. Survey Sectors at Pine Bluff Arsenal

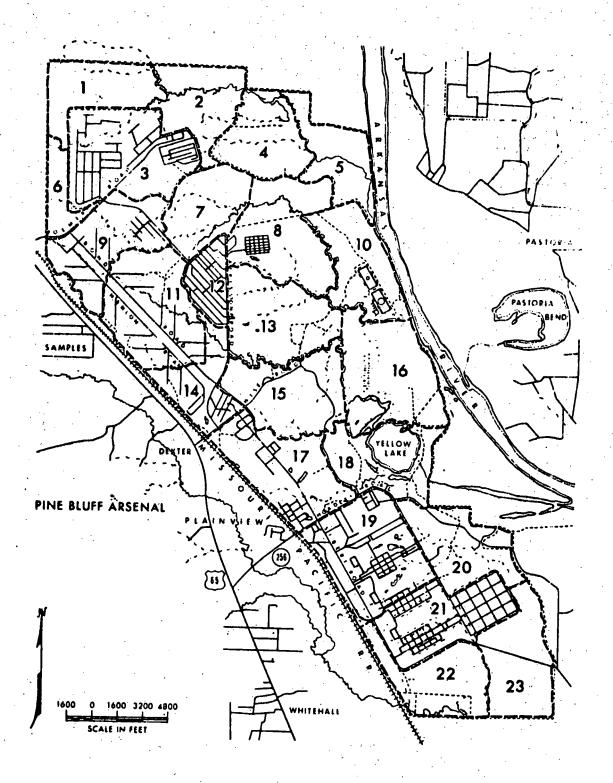


TABLE I.

MAJOR INSTALLATION ACTIVITY ON SURVEY SECTORS

SECTOR	ACTIVITY
1, 2, 4-7, 13, 16, 20, 22, 23	Woodlands managed for timber and recreation
3	National Center for Toxicological Research and Toxic Chemicals storage
8	Toxic chemicals storage, woodlands
9, 11, 14	Munitions storage
10	Munitions testing and open burning
12	Chemicals manufacturing and storage
15	Residential and woodlands
17	Administration
18	Munitions testing, recreation
19, 21	Munitions manufacturing and loading .

7

The first group of sectors (reference sectors) are largely undisturbed.

These sectors were compared with the remaining sectors (experimental sectors) which might have been modified by the activities occurring in them.

II. METHODS

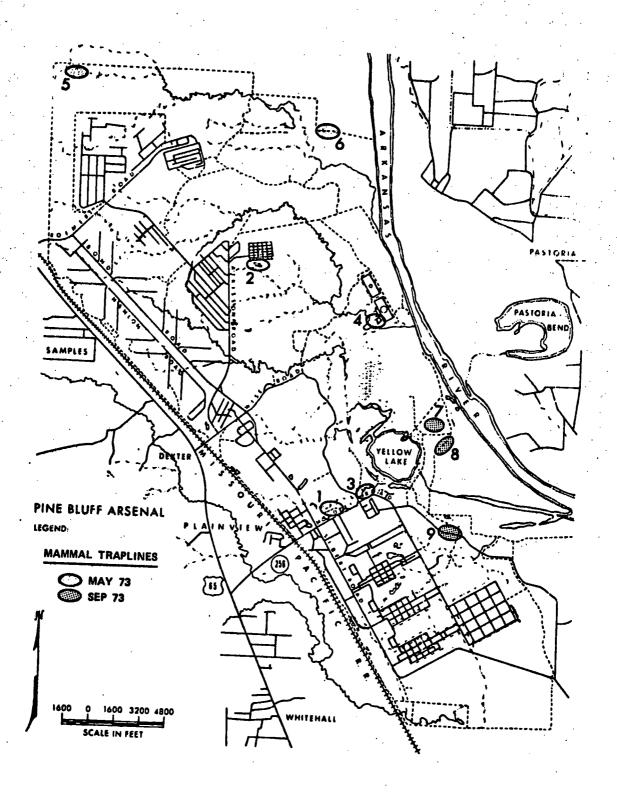
B. Mammals

Mammals were surveyed using live-traps, and by observing them (or their signs) while walking through the sectors or while driving along installation roadways.

Six traplines were established in May 1973. Two lines (numbers 5 and 6) were located in remote areas, and four others were placed in suitable habitat near contaminated areas. Three more traplines were established in September 1973; numbers 7 and 8 along the Arkansas River floodplain, and number 9 in the area of the proposed Central Wastewater Treatment Facility. (Fig 2).

Traplines were set in the early afternoon according to the following schedule: lines 1 and 2 on the first of May; 1, 2, and 3 on the second; 2, 3, and 4 on the third; 3, 4, and 5 on the fourth; 3, 5, and 6 on the fifth; 5 and 6 on the sixth; and line 6 on the seventh. Trapline number 7 was set on the eithteenth and nineteenth of September; 8 on the nineteenth; and 9 on the nineteenth, twentieth, and twenty-first. Aluminum Sherman folding live-traps (9x4x3 and 6x4x3 inches) baited with peanut butter and grain were used for small mammals, and wooden live-traps (24x9x7 inches) baited with peanut butter or canned dog food for larger mammals. Wire traps were used for moles and gophers. The sampling intensity totaled 573 trap nights (the total number of nights that all traps, were set). Each morning, captured animals were anesthetized with Methoxyflurane*, were identified and sexed, their general condition was noted, and they were released at the site of capture. *Forestry Suppliers, Inc., Jackson, Mississippi

Figure 2. Mammal Trapping Sites at Pine Bluff Arsenal



C. Birds

A survey of the birds at PBA was conducted during the daylight hours, on nine consecutive days from 30 April to 8 May, 1973. One night survey was conducted on 3 May during the twilight and evening hours. Species were identified from observation and by a distinctive call. Both migrants and residents were included in the survey. Identifications were made by teams of biologists walking through the sectors, or from vehicles stopping periodically along installation roadways. These routes were not predefined. Equal effort was not devoted to each sector and hence the data are useful only for detecting gross qualitative differences in the species composition between sectors.

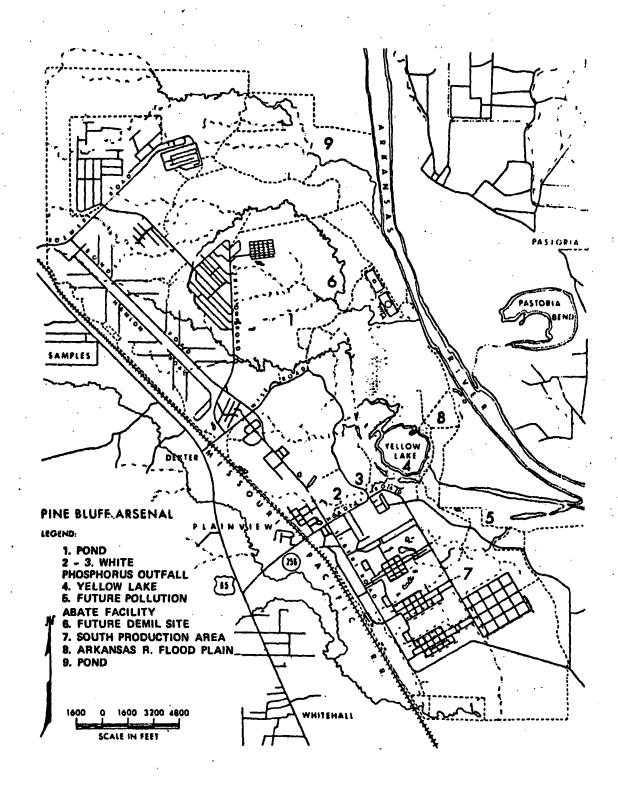
D. Reptiles and Amphibians

Species of reptiles and amphibians were identified,⁵ and their capture location noted, whenever they were encountered (principally by overturning logs) during the surveys of other groups. Tadpoles were collected in temporary ponds in each sector with a dip net. Species of frogs and toads were also recorded when they could be identified by distinctive calls.

E. Plants

A list of vascular plants occurring at PBA was compiled by examining quadrats (100 square meters each) at various locations on the arsenal (Fig. 3). Additional species were included by driving along installation roadways and recording those species that had not been previously observed. The nomenclature follows Gray's Manual of Botany.

Figure 3. Locations of the Plant Quadrats at Pine Bluff Arsenal



Several areas were investigated that appeared to have a disturbed flora and fauna as the result of land contamination from various industrial chemicals.

E. Statistical Analyses

A method of cluster analysis was used in this study to measure similarity between sectors. The first step in this method is to calculate a matrix of similarity values. Sneath and Sokal provide an excellent review of many of the similarity values proposed in the literature. For our analysis we have chosen the Pinkham-Pearson index of biotic similarity, which allows for comparison of sectors based on species abundance and occurrence. The equation for this index is:

$$B = \frac{1}{k} \sum_{i=1}^{k} \frac{\min (X_{1a}, X_{1b})}{\max (X_{1a}, X_{1b})}$$

where k is the number of different species in the samples and X_{ia} and X_{ib} are the number of individuals of the ith species in sample a and b, respectively.

An important feature of this index is that it allows the user to omit matches in which a particular species is absent from both stations (zero-zero matches ignored) or to assign them the maximum value (zero-zero matches equal one). This allows the user to incorporate or exclude mutual absence type data when generating the similarity index depending upon the user's judgement as to the validity of these matches. For example, in a set of data in which there are many rare species, there would also be numerous spurious mutual absence type matches, therefore, the zero-zero

matches ignored option would be the one of choice. However, if the rare occurrences were removed from these data for analysis, then mutual absence type matches would reflect actual similarity between stations and therefore, the "zero-zero matches equal one" option would be preferable.

The second step in cluster analysis is the actual clustering of the resultant similarity values. We have used an unweighted pair-group method which generally introduces less distortion into the clusters. A detailed discussion of this method and cluster analysis in general can be found in Sneath and Sokal. 7

The next step is to display graphically the results of the cluster analysis. Tree-like structures called dendrograms are constructed for this purpose. The scale of similarity is shown across the top of the dendrogram, or tree, which is arranged with its "trunk" at the lowest level of similarity. The similarity level of any cluster may be determined by drawing a vertical line from the level of branching to the scale.

Generally two dendrograms are created from the same data, one for the cluster of surveillance sites and another for the cluster of survey dates. A cluster of species is also created when two or more species are involved. The original data are rearranged in a matrix with the axes in the order indicated by both dendrograms (double-dendrogram order). This results in data points with similar values being arranged together while still maintaining the integrity of the data obtained at the same surveillance sites or on the same survey date. Then a vertical line is drawn in each dendrogram which separates logical clusters of surveillance sites, survey dates or species.

The choice of the level of similarity at which the vertical line is drawn

is somewhat arbitrary, although past experience has shown that lines above a similarity of Q.6, separate groups which usually are not significantly different.

Furthermore the choice is aided by examining the original data rearranged in double-dendrogram order. Lines are drawn through the rearranged data separating the data into subdivisions corresponding to the clusters in both dendrograms indicated by the positions of both vertical lines. Various vertical lines are attempted until logical subdivisions are identified. The vertical lines need not be drawn at the same degree of similarity throughout the dendrogram if more logical subdivisions are indicated by using two different degrees of similarity.

The resulting subdivisions are verified by testing the meaning of each subdivision against the means of all other subdivisions.

The last step is to measure the amount of distortion in the dendrogram caused by the cluster method. This is necessary because the clustering method involves averaging of similarity values in order to express the multidimensional similarity matrix in a two-dimensional, heirarchic relationship. This is accomplished by computing a correlation coefficient between the original similarity values and the ones resulting from the dendrogram. The correlation coefficient is a measure of the amount of distortion introduced by the clustering method.

Since strictly quantitative methods were not used in the bird census study, the data were rendered semiquantitative, i.e., species weighted as abundant = 3, present but not abundant = 1, and absent = 0. Using these values, only those species observed in three or more sectors and the "zero-zero matches ignored"

option, the matrix of similarity values between sectors was calculated.

Statistical tests were conducted using the Student-Newman-Keul's test for differences between multiple means, the <u>aposteriori</u> test of the homogeneity of replicates of proportions or ratios and the chi-square, two-way contingency test for differences between pairs of proportions or ratios. 9 Unless otherwise noted, statistical tests were performed at the 0.05 level.

III. RESULTS

A. Mammals

A total of 13 species of mammals was recorded from 80 observations during the two trapping surveys, and from chance sightings. The signs of four more species were found yielding a total of 16 species of mammals known to occur at PBA (Table II). The most frequently observed species included the White-Tailed Deer, Cotton Rat, White-Footed Mouse, and the Fox Squirrel. There is no statistical difference between the ratios of mammals observed in the reference areas over all sectors.

Results of the mammal trapping survey are presented in Table III.

Results of tests of significance on the rates of trapping success are presented in Table IV. All areas were low, but the area with the highest success, 8, was found to be significantly higher than area 5, with the lowest success.

B. Birds

Sightings of 775 birds comprising 68 species, were recorded during the survey. These species are listed in Appendix 1, along with the sectors in which they were found.

Species encountered five or more times in the same sector during the same day were recorded as being abundant in that sector. Fourteen such species were found to be abundant in one or more survey sectors. The dendrograms of species and sectors are given in Figures 4 and 5. The clusters in the species dendrogram are based primarily upon habitat preferences: Those birds found in cluster A are ones usually found in field margins and fields with bushes. Those in B are usually birds of open fields. Those in C are usually birds of open woods, while those in D are usually birds of dense woods and wood-field ecotones. Lastly cluster E birds are usually found in suburbs and farmlands. The significance of the clusters of sectors will be discussed shortly.

The original data were rearranged in double dendrogram order (Table V) and the clusters from the dendrograms were superimposed creating 15 subdivisions. Table VI presents the results of the tests of these means. Subdivisions 2B-2A have significantly lower means than subdivisions 2D - 1E, with 1B and 3E qualifying for either group of subdivisions. Table VII illustrates the significance of these findings. With the possible exception of species cluster B, all the species in sector cluster 1 were found in significantly high numbers. Sector cluster 2 showed high representation in species cluster D indicating those sectors are primarily heavily wooded. As might be expected from the similarily of habitat preference, clusters of species A and C showed the same result.

C. Reptiles and Amphibians

Eight amphibians and 15 reptile species were recorded from 108 sightings during the survey. These species, and the sectors in which they were found are listed in Table VIII. There was no significant difference between the ratio of reptiles and amphibians in the reference sectors over all species observed and the ratio of reference sectors over all sectors.

Tadpoles were collected in ponds and flowing water as they were encountered in each sector. Their occurrence along with that of aquatic invertebrates was used to evaluate the suitability of these waters to sustain aquatic life. The results of the aquatic investigations in sectors 7, 8, 12, and 13 are detailed in an earlier publication:

D. Plants

A list of vascular plants that were found at PBA during the survey period is included as Table IX.

Several areas were located that have a highly distributed vegetative cover, which is likely due to several types of soil contamination.

Appendix 1. Birds Observed at Pine Bluff Arsenal

CONTION NAME	SCIENTIFIC NAME	SECTOR
MOOD DUCK	AIX SPONSA	8
TURKEY VULTURE	CATHARTES AURA	17, 18
MISSISSIPPI KITE	ICTINIA MISSIPPIENSIS	6, 9
RED-TAILED HAWK	BUTEO JAMAICENSIS	3, 5, 7, 11, 14, 19, 21
BROAD-WINGED HAWK	BUTEO PLATYPTERUS	6, 15
SPARROW HAWK	FALCO SPARVERIUS	7, 11, 12, 18
TURKEY	MELEAGRIS GALLOPAVO	6
BOBWHITE	COLINUS VIRGINIANUS	4, 5, 8, 10, 11, 13, 17-19
GREEN HERON	BUTORIDES VIRESCENS	4
AMERICAN BITTERN	BOTAURUS LINTIGINOSUS	7
KILLDEER	CHARADRUS VOCIFERUS	11, 12, 18, 19
SPOTTED SANDPIPER	ACTITIS MACULARIA	22
ROCK DOVE	COLUMBA LIVIA	12
MOURNING DOVE	ZENAIDURA MACROURA	4, 7-9, 12, 13, 17, 19, 21
CHUCK-WILL'S WIDOW	CAPRIMULEUS CAROUNENSIS	4, 5
CHIMNEY SWIFT	CHAETURA PELAGICA	8, 10, 13, 19

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COMMON NAME	SCIENTIFIC NAME	SECTOR
RUBY-THROATED HUMMINGBIRD	ARCHILOCHUS COLUBRIS	8, 13
YELLOW-SHAFTED FLICKER	COLAPTES AURATUS	1, 4-8, 10, 13, 14, 17-19
RED-BELLIED WOODPECKER	CENTURUS CAROLINUS	5, 8, 10, 13, 17-20
PILEATED MOODPECKER	DRYOCOPUS PILEATUS	4, 10, 13, 18, 19
RED-HEADED WOODPECKER	MELANERPES ERYTHROCEPHACUS	6, 8-10, 13, 14
DOWNY WOODPECKER	DENDROCOPOS PUBESCENS	8, 10, 18-20
EASTERN KINGBIRD	TYRANNUS TYRANNUS	8, 10, 13-15, 17-19, 21
GREAT CRESTED FLYCATCHER	MYIARCHUS CRINITUS	10
EASTERN WOOD PEWEE	COLTOPUS VIRENS	18
BARN SWALLOW	HIRUNDO RUSTICA	7, 12, 17, 18
ROUGH-WINGED SWALLOW	STELGIDOPTERYX RUFICOLLIS	18
PURPLE MARTIN	PROGNE SUBIS	7, 8, 18
BLUE JAY	CYANOCITIA CRISTATA	1, 5, 6, 8-10, 13-15, 17-19, 21-23
COMMON CROW	CORVUS BRANCHYRHYNCHOS	6, 18, 21
FISH CROW	CORVUS OSSIFRAGUS	13, 18
CAROLINA CHICKADEE	PARUS CAROLINENSIS	1, 4, 6-8, 10, 13, 18, 20
TUFTED TITMOUSE	PARUS BICOLOR	1, 6, 8, 10, 13, 17, 18, 20, 21, 23

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COMMON NAME	SCIENTIFIC NAME	SECTOR
RED-BREASTED NUTHATCH	SITTA CANADENSIS	1, 18
WINTER WREN	TROGLODYTES TROGLODYTES	4, 5, 10, 20
CAROLINA WREN	THRYOTHORUS LUDOVICIANUS	4-6, 8-10, 13, 17-19, 21
MOCKINGBIRD	MIMUS POLYGLOTTOS	4, 5, 8-10, 12-15, 17-19, 23
CATBIRD	DUMETELLA CAR LINENSIS	4, 18
BROWN THRASHER	TOXISTOMA RUFUM	1, 4, 8-10, 19, 23
ROBIN	· TURDUS MIGRATORIUS	13-15, 17
WOOD THRUSH	HYLOCICHLA MUSTELINA	4, 5, 9, 10, 13
SWAINSON'S THRUSH	HYLOCICHLA USTULATA	8
EASTERN BLUEBIRD	STALTA STALTS	6, 7, 9, 11, 13, 17-19, 21
STARLING	STURNUS VULGARIS	8, 12-15, 17, 19, 21
WHITE-EYED VIREO	VIREO GRISEUS	10
WARELING VIREO	VIREO GILVUS	23
WORM-EATING WARBLER	HELMITHEROS VERMIVORUS	1
BLACK-THROATED GREEN WARBLER	DENDROICA VIRENS	1, 23
MYRTLE HARBLER	DENDROICA CORONATA	1, 8-10
CERULEAN HARBLER	DENDROICA CERULEA	8

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COMMON NAME	SCIENTIFIC NAME	SECTOR
WARBLER	AMERICANA	13
YELLON THROAT	GEOTHLYPIS TRICHAS	4, 5
YELLOW-BREASTED CHAT	ICTERIA VIRENS	1, 5, 8, 17, 18, 23
EASTERN MEADOWLARK	STURNELLA MAGNA	3, 7, 8, 12-15, 17, 19, 21
RED-WINGED BLACKBIRD	AGELATUS PHOENICEUS	5, 8, 17-19, 21
COMMON GRACKLE	QUISCALUS QUISCULA	10, 21
BROHN-HEADED COWBIRD .	MOLOTHRUS ATER	7, 8, 10, 13, 15, 17
BALTIMORE ORIOLE	ICTERUS GALBULA	8, 10, 18, 23
SUMMER TANAGER	PIRANGA RUBRA	1, 6, 8, 10, 13, 17-19, 23
CARDINAL	RICHMONDENA CARDINALIS	1, 4, 6, 8, 10, 13-15, 19, 21
BLUE GROSBEAK	SUIRACA CAERULEA	3, 18
INDIGO BUNTING	PASSERINA C ANEA	4, 5, 13, 19, 21
PINE SISKIN	SPINUS PINUS	17
AMERICAN GOLDFINCH	SPINUS TRISTIS	4, 22
CHIPPING SPARROW	SPIZELLA PASSERINA	8, 18, 19
FIELD SPARROW	SPIZELLA PUSILLA	8
WHITE-THROATED SPARROW	ZONOTRICHIA ALBICOLLIS	4
HOUSE SPARROW	PASSER DOMESTICUS	17, 19

Beavera

Bobcat

Armadillo^d

TABLE II MAMMALS OBSERVED AT PINE BLUFF ARSENAL

COMMON NAME **Opossum** Shorttail Shrew Raccoon STRIPED SKINK Eastern Gray Squirrel Eastern Fox Squirrel Plains Pocket Gopher Fulvus Harvest Mouse White-Footed Mouse Hispid Cotton Rat Eastern Cottontail White-Tailed Deer

SCIENTIFIC NAME Didelphis Marsupialis Blarina brevicauda Procyon lotor Mephitis mephitis Sciurus canadensis Sciurus niger Geomys bursarius Reithrodontomys fulvescens Peramyscus leucopus Sigmodon hispidus Sylvilagus floridanus Odocoileus virginianus Castor canadensis Lynx rufus

Dasypus novemcinctus

TABLE II continued

Coyote

Muskrat

River Otter C

Canis latrans

<u>Ondatra zibethica</u>

Lutra canadensis

^aSightings of tracks or nesting areas

^bSectors as in bird survey

^CObserved during an aquatic survey May, 1976

Sector

17, 18

20

6, 8, 13

18

13, 14

7, 9, 13-15, 17-20

14, 18

16

13, 10, 17, 18

5, 17, 18

8, 13, 15, 19-21

4, 5, 6, 8, 13-15, 20, 21

16, 18

14

16

13

15

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TABLE III
RESULTS OF MAMMAL TRAPPING SURVEY. RATIO INDICATES CAPTURE PER NUMBER OF TRAPS SET

TRAPP	ING DATE						•					3
AREA	MAY 1	2	, 3	4	5	, 6	7	SEPTEMB 18	ER 19	20	21	
1	1/30	2/30										3,
2	0/27	0/27	.2/27						•			2.
3-L		4/22	1/22	3/22	2/22		•				•	10,
4			2/25	3/25		•			.	-		5,
5-5				0/26	0/26	0/26				,		0
. 6					0/24	0/27	2/27					2
7		.*			·		•.	0/24	2/24	·		2.
8-L									1/3			1
9-5								•	0/29	1/29	0/29	1
Total	s 1/57	6/79	5/74	6/73	2/72	0/53	2/27	0/24	3/56	1/29	0/29	26/

TABLE IV

RESULTS OF THE TESTS OF SIGNIFICANCE BETWEEN SUCCESS RATES FOR THE DIFFERENT MAMMAL TRAPPING LOCALITIES

				AREA				•	· ·	
;	8	3	4	1	7	6	2	9	5	Tol
Success	1	10	5	3	2.	2	2	. 1	0	21
Failures	2	78	45	57	46	76	79	86	78	541
Total	3 ,	88	50	60	48	78	81	87	78	571
% Trappings	0.333	0.110_	0.100	0.050	0.042	0.026	0.025	0.011	0.000	
Success			·.			· 				
	·									

^aThe line extends beneath those areas determined to be homogeneous.

Figure 4. Dendrogram of Bird Species at Pine Bluff Arsenal
Based Upon Sectors

Figure 5. Dendrogram of Sectors at Pine Bluff Arsenal Based
Upon Bird Species

BIRD DATA REARRANGED IN DOUBLE DENDROGRAM ORDER

_																							
)			2							3								
		17	19	8	10	13	18	4	5	9	1	6	23	14	15	21	7	12	11	3	22	20	
1	RED-TAILED HAWK	0	1	0	0	0	0	0	1	0	0	. 0	0	1	0	1	1	0 ·	1	1	0	0	
30	RED-WINGED BLACKBIRD	. 1	1	3	0	0	3	0	ĭ	0	0	0	0	0	1	0	0	0	0	0	0	0	
5	MOURNING DOVE	1	1	1	0	1	0	0	1	1	3	0	ο.	0	Ð	1	1	1	0	0	0	e .	
25	EASTERN BLUEBIRD	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1	1	0	1	0	0	ű P.	
35	INDIGO BUNTING	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	
16	COMMOM CROW	υ	0	0	0	0	3	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	
2	SPARROW HAWK	0	0	0	0	0	1	0	0	0	. 0	0	0	0	0	0	1	1	1	0	0	0	
4	KILLDEER	ß	1	0	0	0	1	0	0	0	0	0	٥	0	0	0	0	1	1	0	0	0	
13	BARN SWALLOW	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
14	PURPLE MARTIN	0	. 0	3	0	0	1	0	G	0	0	0	0	0	0	0	1	0	0	0	0	0	
6	CHINNEY SWIFT	0	1	3	1	1	0	0	0	0	0	G	0	0	0	0	0	0	0	0	0	0	
9	PILEATED WOODPECKER	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	BOBWHITE	3	3	1	. 1	1	1	0	0	0	0	0	0	0	0 -	0	0	0	1	0	0	0 C	
8	RED-BELLIED WOODPECKER	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	

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TABLE V.

•		· .																		_			
					1							2		•						3	,		
		17	19	. 8	10	13	18	4	5	9	1	6	23	14	15	21	7.	12	11	3	22	20	
11	DOWNEY WOODPECKER	0	1	1	. 1	0	1	1	0	0	0	0	0	0	0	0	· • 0	0	0	0	0	1-1-	
36	CHIPPING SPARROW	0 -	1	1	0	0	1	0	- 0	- 0	0	0	0	0	0	0	0	0	0	0	0	0	
28	YELLOW-BREASTED CHAT	1	0	1	0	0	1	0	'0	0.	1	Q	1	0	0	0	0	0	0	0	0	Ò.	
32	BALTIMORE ORIOLE	0	. 0	. 1	1	0	1	0	0	0	. 0	0	-1	0 ,	0 .	0	0	. 0	0	0	0	. 0	
12	EASTERN KINGBIRD	1	1	3	1	1	1	O,	1	.0	0	0	0	'n	1	1	0	0	0		0	0	
34	CARDINAL	0	1	1	1	1	0	0	1	0	1	1	Ö	. 1	1	٠ ٦	0	0	0	0	۰ ٥	0	
7	YELLOW-SHAFTED FLICKER	1	1	1	1	1	1	0	0	0	1.	1	0	1	0	. 0	1	0	0	0	0	0	
20	CAROLINA WREN	1	, 1	1	1	1	1 -	0	1	1	0	1	0	0	0	1	. 0	0	0	0	0	0	
15	BLUE JAY	1	j	1	1	. 1	1	0	3	1	1	1	3	3	1	3	0	,0	O '	0	1	0	
21	MOCKINGBIRD	1	1	1	1	1	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0 D	
1	TUFTED TITMOUSE	. 1	0	1	1	1	1	1	1	Ó	1	. 1	1	o d	0	1	0	0	0	0	0	1	
33	SUMMER TANAGER	, 1	1	1	1	1	1	. 0	0	0	1	1	1	0	. 0	0	0	0	0	0	0	0	
17	CAROLINA CHICKADEE	0 -	0	1	1	1	1.	1	0	0	1	1	0	0	0	0	1	0.	, o	0	0	0	
10	RED-HEADED WOODPECKER	0	0	1	ij	1	0.	0	0	1	0	1	0	7	0	O,	0	0	0 .	0	0	0	
22	BROWN THRASHER	0	ì	. 1	1	0	0	0	0	1	1	0	1	0	0	0	0	. '0	0.	0	0.	0	٠,

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TABLE V. Continued

										_														
				1	l			2								3								
		17	19	8	10	13	18	4	5	9	1.	6	23	14	15	21	7	12	13	3	22	20		
27	MYRTLE WARBLER	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0.	0	0	D	
19	WINTER WREN	0	0	0	1	0	0	1	. 0	0	0	0	0	0	0	0	0	. 0	0	0	0	0 '	J	
24	WOOD THRUSH	0	0	0	1	1	0	0	<i>></i> 0	1	0	0	0	0	0	0.	0	0	0	0	0	0		
26	STARLING	3	3	1	0	1	0	0	1	0	0	0	0	1	1	1	0	3	0	0	0	1		
29	EASTERN MEADOWLARK	1	1	1	0	1	0	0	1	0	0	0	0	1	1	1	1	1	. 0	1	0	i	c	
23	ROBIN	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	•	
31	BROWN-HEADED COWBIRD	3	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0		

TABLE VI.

RESULTS OF TESTS OF SIGNIFICANCE BETWEEN THE MULTIPLE MEANS OF THE SUBDIVISIONS IN THE REARRANGED BIRD DATA

Subdivisions		Means	Regions of Homogeneity of Means
2B .	·	.0000	
3 D		.0595	
3C		.0625	
2C		.0694	
3A	•	.1944	
2E		.3056	
3B		.3333	
2A		.3704	
1B	• '	.3750	
3E		.3750	
2 D		.4524	
1A		.6111	
10		.7381	1
10	•	.8125	
1E		.8333	l l

TABLE VII.

THE RELATIONSHIP BETWEEN THE SUBDIVISIONS OF THE REARRANGED BIRD DATA

		*	Clusters of	Sectors		<i>a</i>
1		2	and the second second		.3.	Clusters of Species
High		Low			Low	A
High	. •	Low			Low Low	B C
High High	· v	High			Low	D
		Low		en en		Ě

TABLE VIII.

****OHIBANS AND REPTILES OBSERVED AT PINE BLUFF ARSENAL

SCIENTIFIC NAME	COMMON NAME	SECTOR
11 <u>Coluber Constrictor</u> <u>Priapus</u>	SOUTHERN BLACK RACER	18
3 <u>Terrapene Carolina</u> <u>Triunguis</u>	THREE-TOED BOX TURTLE	4,8,18.20
4 Pseudemys Scripta Elegans	RED-EARED TURTLE	8,15,17,18,23
l <u>Chelydra Serpentina</u> <u>Serpentina</u>	COMMON SNAPPING TURTLE	8,14
22 Rana Clamitans Melanota	GREEN FROG	4,5,8,10,18,21,2
12 Opheodrys Aestivus	ROUGH GREEN SNAKE	19
9 <u>Natrix Rhombifera</u> <u>Rhombifera</u>	DIAMOND-BACKED WATER SNAKE	18
16 <u>Siren Intermedia</u>	LESSER SIREN	4, 18
Agkistrodon Contortrix Contortrix	SOUTHERN COPPERHEAD	7, 18
19 Acris Crepitans	CRICKET FROG	4,5,8,12,18,19
2 <u>Kinosternon Subrubrum</u> <u>Hippocrepis</u>	MISSISSIPPI MUD TURTLE	19
18 Bufo Woodhousei Fowleri	FOWLER'S TOAD	1,5,8,13,18
17 Bufo Americanus Charlesmithii	DWARF AMERICAN TOAD	10,13,20
20 Gastrophyrne Carolinensis	EASTERN NARROW-MOUTHED TOAD	10,21
7 Lygosoma Laternale	GROUND SKINK	10,20
23 Rana Pipens Sphenocephela	SOUTHERN LEOPARD FROG	8,18
21 Rana Catesbiana	BULLFROG	17,18
15 Agkistrodon Piscivorus Leucostoma	WESTERN COTTONMOUTH	13,18
8 Ophisaurus Attenuatus Attenuatus	WESTERN SLENDER GLASS LIZARD	18

TABLE VIII. (Continued)

SCIENTIFIC NAME	COMMON NAME.	SECTOR
5 Sceloporus Undulatus Hyacinthinus	NORTHERN FENCE LIZARD	1,6,7,10
14 Crotalus Horridus Atricaudatus	CANEBRAKE RATTLESNAKE	10
6 Cnemidophorus Sexlineatus	SIX-LINED RACERUNNER	5,10
10 Thampophis Sauritus Proximus	WESTERN RIBBON SNAKE	13

TABLE IX.
PLANTS OBSERVED AT PINE BLUFF ARSENAL

Scientific Name	<u>Family</u>	Common Name	Area
Acalypha setosa	Euphorbiaceae		7
Acalypha sp.	n	•	6
Acer rubrum L.	Aceraceae	Red Maple	1,3
Aesculus pavia L.	Hippocastinaceae	Red Buckeye	9
Agrostis hyemalis (Walt.) BSP	Gramineae		4
A. perennans (Walt.) Tuckerm.	u		2
Ambrosia bidentata Michx.	Compositae	Ragweed	2,7
A. rugelii	n	n	7
Ampelopsis arborea (L) Koehne	Vitaceae	Pepper Vine	6,8
Cenchrus tribuloides	Gramineae	Sand-bar Grass	7 .
Andropogon gerardi	Vitm.	Turkeyfoot or Big Bluestem	7,9
A. scoparius Michx.	n	Little Bluestem	1,5
A. ternarius Michx.	u ;	Silver Beardgrass	7
Aralia spinosa L.	Araliaceae	Hercule's Club	5

Scientific Name	Family	Common Name	Area
Aristida dichotoma Michx.	Gramineae	Poverty Grass	7,10
Ascyrum hypericoides L.	Hypericaceae	St. Andrew's Cross	2,5
Aster lateriflorus (L) Britt.	Compositae	Aster	4
A. patens Ait.	a	a	2,3
Azolla caroliniana Willd.	Salviniaceae	Water Velvet	4
Baccharis halmifolia L.	Compositae	Groundsel-tree	1
Berchemia scandens (Hill) Trel.	Rhamnaceae	Supple-jack	4,6
petula lutea Michx. var. macrolepis Fern.	Corylaceae	Yellow or Gray Birch	3
Bidens aristosa (Michx.) Britt.	Compositae	Beggar's Ticks	4
8. Polylepis Blake	ti	n H	5
Boehmeria cylindrica (L) Sw.	Urticaceae	False Nettle	4,6,7
Cardiospernum halicacabum L.	Sapindaceae	Heart Seed	4
callicarpa americana L.	Verbenaceae	French Muhlberry	8
Carya illinoensis (Wang) K. Koch	Juglandaceae	Pecan	3,5,8
C. texana Buckl.	n		9
campsis radicans (L) Sam.	Bignoniaceae	Trumpet Creeper	8

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TAb. IX. Continued

Scientific Name	<u>Family</u>	Common Name	Area
Carya tomentosa Nutt.	Juglandaceae	Mockernut Hickory	2,9
Cassia fasciculata Michx.	Leguminosae	Partridge Pea	2,8
c. marilandica L.	81		5
Castanea pumila (t) Mill.	Fagaceae	Chinquapin	2
celtis laevigata Willd.	Ulmaceae	Hackberry	6,8,10
cephalanthus occidentalis L.	Rubiaceae	Buttonbush	4,9
cocculus carolinus (L) DC	Menispermaceae	Red berried Moonseed	4
conyza canadensis			8
Cornus florida L.	Cornaceae	Flowering Dogwood	1-3,6
C. racemosa Lam.	n	Gray Dogwood	8
Crataegus sp.	Rosaceae	Hawthorn	6
Croton capitatus Michx.	Euphorbiaceae	Hogwort	1,7
Cynodon dactylon (L) Pers.	Gramineae	Bermuda Grass	7,8,10
Cyperus erythrorhiza Muhl.	Cyperaceae		4
C. strigosus L.	n .		4
Digitaria ischaemum (Schreb.)	Gramineae	Smooth Crabgrass	4,10
D. sanguinalis (L) Scop.	. н	Crabgrass	8,10

Scientific Name	Family	Common Name	Area
Diodia teres Walt.	Rubiaceae	Buttonweed	2,4,7
D. virginiana L.	n	Buttonweed	6,7,9
Diospyros virginiana L.	Ebenaceae	Persimmon	1,2
Eclipta alba (L) Hassk.	Compositae	Yerba-de-Tago	4
Schultes (Willd)	Cyperaceae	Slendor Spikerush	6
Elymus virginicus L.	Gramineae	Wild Rye	2
Eragostis spectabilis (Pursh) Steud.	Gramineae	Tumble Grass	1,7
Erechtites hieracifolia (L) Raf.	Compositae	Fireweed	1
Erianthus alopecuroides (L) Ell	Gramineae	Woolly Beardgrass	4
Erianthus sp.	u .	•	1
Eupatorium coelestinum L.	Compositae		4
E. perfoliatum L.	u	Boneset	2,4-7
E. rotundifolium L.	11	• • • •	4
Euphorbia maculata L.	Euphorbiaceae	, Martweed	7,8
E. corollata L.	n		2
Fraxinus lanceolata Borkh.	01eaceae	Green Ash	5,6,8,10

TAbLE IX. Continued

Scientific Name	Family	Common Name	Area
Froelichea floridana (Nuttall) Noq.	Nyctaginaceae	Cottonweed	8
Gerardia purpurea L.	Scrophulariaceae	Purple Gerardia	1,5,7
G. tenuifolia Vahl.	a		5,8
Mollugo verticillata L.	Aizoaceae	Carpetweed	8
Monarda punctata L.	Labiatae	Horsemint	8
Morus rubra L.	Moraceae	Red Mulberry	4 ,
Myrica cerifera L.	Myricaceae	Wax Myrtle	1.1
Nelumbo lutea (Willd) Pers.	Nymphaceae	Yellow Lotus	4
Nyssa aquatica L.	Nyssaceae	Water (Cotton) Gum	10
N. sylvatica Marsh.	B	Sour Gum or Tupelo	2,3
Panicum agrostoides Spreng.	Gramineae	Panic Grass	4,5
P. depauperatum Muhl.	Ħ	tt 17	5,8
P. dichotomoflorum Michx.	n	60 BE	5
P. microcarpon Muhl.	8	10 11·	5,6
P. villosissimum Nash	n	6 ts	1,3
Parthenocissus quinquefolia (L) Planch	Vitaceae	Virginia Creeper	4

TADLL IX. Continued

			·	
	Scientific Name	<u>Family</u>	Common Name	Area
	Paspalum ciliatifolium Michx.	Gramineae	Paspalum Grass	5,7
	P. dilatatum Poir.	## · · · · · · · · · · · · · · · · · ·	ti di	7,10
	P. urvillei Steud.	B	n u	8
•	Passiflora lutea L.	Passifloraceae	Passion Flower	2
	Persea borbonia (L) Spreng.	Lauraceae	Red-Bay	2
	Pilea pumila (L) Gray	Urticaceae	Richweed	7
	Pinus echinata Mill.	Pinaceae	Short-leaf Pine	2,9
5	P. taeda L.	tt .	Loblolly Pine	1-3,5
	Plantago rugelli Dcne.	Plantaginaceae	Rugel's Plantain	7
_	Polygonum hydropiper L.	Polygonaceae	Water Pepper	4
	P. hydropiperoides Michx.	, 9	Mild Water Pepper	4
	P. pensylvanicum L.	u	Pennsylvania Knotweed	4
	Populus deltoides Marsh.	Salicaceae	Northern Cottonwood	. 7
	Prunus serotina Ehrh.	Rosaceae	Black or Rum	5,7-10
	Pteridium aquilinum (L) Kuhn	Polypodiaceae	Bracken Fern	1,2
. • •	Quercus alba L.	Fagaceae	White Oak	2,3
	Q. falcata Michx	et .	Southern Red Oak	1-3

Scientific Name	Family	Common Name	Area
Quercus palustris Muenchh	M	Pin Oak	10
Q. Phellos L.	u Y	Willow Oak	1,3
Q. shumardii Buckl.	tt	Shumard's Red Oak	10
Q. stellata Wang.	Ħ	Post Oak	1-3
Q. velutina Lam.	u ·	Black Oak	2
Rhexia virginica L.	Melastomataceae	Deer Beauty	4
Rhus copallinum L.	Anacardiaceae	Dwarf Sumac	2,3,5
Rhus toxicodendron L.	n	Poison Ivy	· · · 6
Rhyrehaspora sp.	Cyperaceae	Beak Rush	1
Salix. nigra L.	Salicaceae	Black Willow	4,7
Sambucus caradensis L.	Caprifoliaceae	Common Elder	5
Sassafras albida (Nutt)	Lauraceae	Sassafras	1
Sourarus cernus L.	Saururaceae	Lizard's Tail	4
Scirpus sp.	Cyperaceae	Bull Rush	1
	• .		
Smilax rotundifolia L.	Liliaceae	Bull Briar.	6
Smilax glauca Walt.	a ·	Catbriar	1,5

Scientific Name	Family .	Common Name Area	
		Common Green Briar	
Solidago altissima Ait.	Compositae	Goldenrod 7,8	
S. odora Sit.	u	Sweet Goldenrod 1-3	
	e de la companya de l	Goldenrod 8	
	Gramineae	Johnson Grass 4,8	
	Làmnaceae	Duc kweed 4	
	Gramineae Leguminosae	Poverty Grass 7 Wild Bean 2,7-10	
Taxodium distichum (L) Richard	Pinaceae	Bald Cypress 4	
Trachelospernum difforme (Walt) Gray	Apocynaceae	Climbing Dogbane 4	
Trifolium repens L.	Leguminosae	White Clover	
Ulmul alata Michx.	Ulmaceae	Winged Elm 4-6	e period of the second of the
Uniola laxa (L) BSP	Gramineae.	1.2	1
Vaccinium arboreum Marsh	Ericaceae	Farkleberry	

TABLE IX. Continued

Scientific Name	Family	Common Name	Area
Verbena cf. encelioides (Cav.) B & H	Compositae		4.
Veronia peregrina L.	Compositae	Ironweed	4
Vitis aestivalis Michx.	Vitaceae	Summer Grape	2,4
V. rotundifolia Michx.	a	Muscadine Grape	1-4
Woodwardia areolata (L) Moore	Polypodiaceae	Netted Chain Fern	1
Xanthium strumarium L.	Compositae	Cocklebur	7

Locations of plant survey areas shown in Fig. 3. Area 10 refers to partly cultivated and roadside.

Discussion

The surveys described in this report detected a number of areas with disturbed vegetation. Prompted by our initial findings we investigated further and found that some were contaminated with various manufacturing wastes. Although the locations of all these areas were not known at the time the survey sectors were selected, it now seems prudent to analyze the data using the additional information.

Sector 12, the abandoned North Production Area, was used as a manufacturing area for mustard-filled munitions, lewisite, DDT, chlorine, and sulfuric acid. The surfaces of the buildings are so contaminated with mustard agent that they cannot be safely dismantled. Open dumps of waste DDT in this area are constantly eroded by surface runoff, and hence the receiving tributaries are also heavily contaminated. Arsenic is potentially present from the past production of lewisite.

Sector 8, containing the toxic gas storage yard, is a good example of a largely undisturbed sector. However; a fraction of Sector 8, just south of the storage yard is severly damaged. This function consists of a borrow pit (where fill dirt was excavated) which was used for the disposal of mustard. During the disposal procedure, decontamination material was disced into the soil, which is now so damaged that invading weeds are unable to colonize the area.

Sector 10 includes a munitions test area and is reported to be contaminated with Chloroactophenone (CN), a tear agent, Adamsite (DM), a vomiting agent, pyrotechnics, munitions, smokes and incendiaries (T. Shook, oral communication). The area surrounding Yellow Lake (sector 18), its feeding tributaries, and the lake itself are contaminated with elemental phosphorous, DDT, pyrotechnics and munitions.

A. Mammals

Nothing in the data on mammals sighted indicates a generally adverse effect of PBA activities. The trap site with a success rate which was significantly lower than the site with the highest rate was in an area known to be free of disturbances. The rodent populations were low compared with similar populations elsewhere ^{10,11} while potential predators (at least six species of predatory mammals, four species of birds of prey, and four species of predatory snakes) were relatively common. Whether the mammal population was at a low in a cyclic pattern¹² or a balance had been reached between the food source, cover and predator pressure could not be determined.

B. Birds

Bird population exhibited no adverse effects from the activities at PBA.

There were both numerous species and individuals. The result of the dendrogram analysis does not follow the control versus experimental sectors described in the Materials and Methods sector. Rather, in retrospect, it closely follows the sectors where most of the time was spent: Sectors in category 1 were visited most frequently, those in category 2 were visited less frequently and those in category 3 were visited least frequently. In this regard sectors 2 and 16 which were not clustered because of insufficient data were not studied at all. The only exception was area 12 which was heavily contaminated (see above) and was studied intensely. All other sectors apparently had sufficiently diverse habitats and healthy populations so that adverse effects, if any, were masked.

C. Amphibians and Reptiles

Amphibians and reptiles were well represented, and apparently showed no widespread adverse effect. Nor was there significantly fewer species of amphibians in the experimental areas. In a few limited pond and stream locations in sectors

12 and 13 amphibians and aquatic invertebrates were absent. The pH conditions were unacceptable to sustain life. 2

D. Conclusions

Most of the land areas of PBA appear to be environmentally healthy on a gross scale. However certain sections, the largest of which occurs in sector 12, are severly contaminated with decontamination products, munitions wastes, and pesticides remaining from the sloppy manufacturing and disposal techniques of the past. Each rainfall erodes more of these contaminants into the surrounding streams thus spreading the effects through the environment. Therefore the major impact of these relatively limited sources of terrestrial disturbances are found in studies of aquatic systems. The terrestrial impacts of the installation activities should be studied in detail at specific problem areas identified in this report. It appears that the studies should include soil invertebrates and bioaccumulation of pesticides, heavy metals, and elemental phosphorous in some of the common vertebrates.

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APPENDIX G

USA ENGINEER WATERWAYS EXPERIMENT STATION
LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARACTERISTICS
AT PINE BLUFF ARSENAL
FEBRUARY 1976

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A LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARATERISTICS.
AT PINE BLUFF ARSENAL, ARKANSAS

by:

Jerald D. Broughton

Soils and Pavements Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

February 1976 Draft Report

Prepared for U. S. Army, Pine Bluff Arsenal Pine Bluff, Arkansas 71601

SUMMARY

Personnel of the Waterways Experiment Station (WES) visited or contacted eleven Federal or State organizations to collect data relevant to the hydrogeological regime of a north-central portion of the Pine Bluff Arsenal (PBA). Attention was focused on collecting and reviewing topography, soils, geology, and hydrology information.

These data were examined and, where necessary, translated to formats which were more applicable to the hydrogeologic descriptions. Data are discussed and presented as tables, figures, and plates illustrating surface soils, subsurface soils, slope, permeability, landforms, drainage, piezometric surfaces, and precipitation.

According to the data collected and extrapolated, the PBA ranges in elevation from 200 to 300 ft mean sea level (msl) and is underlain, in part, by a piezometric surface approximating 190 to 195 ft msl. The gently sloping surfaces are predominantly silts with infiltration being retarded by hardpans in the shallow subsurface. The precipitation is approximately 50 in. with an excess of potential evaporation.

Based upon available data and program requirements, a detailed plan of sampling and analysis was included.

PRELIMINARY

PREFACE

The study reported on herein is a portion of the Pine Bluff Arsenal*
(PBA) Engineering and Technology Directorate's program to assess the potential groundwater pollution by past or ongoing activities of the Arsenal. The study is an initial phase of a more complete program described in Appendix A; authority to conduct this study was given by PBA to the Waterways Experiment Station (WES) by teletype dated 3 November 1975, subject: "FJ6 P1856FJQ6."

The study was conducted during the period of November 1975 to
January 1976 by personnel of the Engineering Geology and Rock Mechanics
Division (EGRMD), Soils and Pavements Laboratory (S&PL). The study aims
and approach were reviewed by personnel of the Mobility and Environmental
Systems and Environmental Effects Laboratories prior to execution.
Mr. Jerald D. Broughton was responsible for the conduct of the study and
preparation of this report. He was assisted by Messrs. Harry K. Woods,
Donnie E. Andrews, and Mrs. Marilyn B. Worthy. All portions of the work
were under the direct supervision of Mr. John H. Shamburger, Chief,
Terrestrial Sciences Branch, and under the general supervision of Mr. Don
C. Banks, Chief, EGRMD, and Messrs. James P. Sale and Richard G. Ahlvin,
Chief and Assistant Chief, respectively, of the S&PL.

Director of the WES during the conduct of this study and preparation of this report was COL G. H. Hilt, and Technical Director was Mr. F. R. Brown.

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6

PRELIMINARY,

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

The following table is given so that units used in this report can be converted from British to metric equivalents.

Multiply	
inches 2.54	To Obtain
feet 0.3048	centimeters
miles 1.609344	meters kilometers
acres 0.4047	hectares
in./hr 0.000706	cm/sec
in./year 2.54	
	cm/year

A LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARACTERISTICS AT PINE BLUFF ARSENAL, ARKANSAS

PART I: INTRODUCTION

Background

- 1. The PBA has been in operation for over 30 years; during that time the Army as well as private firms under lease agreements have manufactured substances that have been handled, stored, or discarded in such a manner that potential pollution problems exist in the surface water and groundwater at the PBA. Recent observations and studies at the Rocky Mountain Arsenal have provided an insight to the magnitude of potential contaminant problems associated with these types of operations. Studies, starting in 1966 and continuing to the present, have been made by the PBA, Edgewood Arsenal (EA), the U. S. Army Environmental Hygiene Agency (AEHA), and WES to examine different portions of the potential problem. Advice and guidance for continuing studies are currently given by the Chemical Demilitarization and Installation Restoration group of the Army Materiel Command.
- 2. The PBA has determined that several areas of the installation are, or have been, subject to surface accumulation of materials which are potential sources of contamination. The studies to date have provided a definitive understanding of contaminant problems associated with surface waters and have led to planned actions to treat this aspect of the problem. To date, however, little or no understanding exists for evaluating the potential contamination of groundwater at the PBA.
- 3. The WES was requested to make a hydrogeological site assessment of one area (consisting of two sites) at the PBA. The assessment will be completed in FY 1977 and will result in the site description and determination of parameters required to determine the present extent of any groundwater pollution as well as to anticipate or predict future trends. The study reported herein is the initial phase of the assessment; specifically, data relating to subsurface conditions (and surface

conditions, as relevant) were collected and examined to determine the extent and details of available information and to enable firm plans to be made for the remaining phases of the hydrogeological study.

Purpose and Scope

Purpose

- 4. The purpose of this study is to determine sources of information pertaining to the subsurface (and the surface, as relative), to collect available data and to evaluate the information as it pertains to a hydrogeological description and parameters necessary to make a hydrogeological study of a specified disposal area at PBA (see Figure 1). This information will assist in recommending a plan of action to generate required hydrogeological data for the study area in the future. Scope
- 5. This study is concerned with some 65 acres located in the north-central portion of the PBA as shown on the topographic map 1* (Figure 1). While attention was focused on this area during data collection and evaluation, the search for data and subsequent development of a recommended plan of action, required collection and evaluation of information covering the entire reservation, Jefferson County, Arkansas, and/or the south-central United States for background purposes.
- 6. Inquiries were made to both Federal and State agencies as well as applicable military installations to secure information required for the study. All maps were prepared without the benefit of any on-site field data collection.

^{*} Raised number indicates entries similarly numbered in Reference list.



PART II: LITERATURE SURVEY

Approach

- 7. Since a wide spectrum of data exists, to make the study meaningful to a hydrogeologic assessment, those factors that cause or influence
 movement of contaminants on the surface or through the subsurface from
 its present disposal location were determined. Those factors were
 considered to be:
 - a. Soil type (surface and subsurface)
 - b. Landforms
 - c. Topographic slope
 - d. Surface and subsurface drainage (permeability)
 - e. Rainfall (amount, intensity, and frequency)
 - f. Groundwater conditions (depth and thickness)
 - g. Depth to bedrock

Data search

- 8. The search at WES for data pertaining to the above factors consisted of obtaining a computerized data listing from the Defense Documentation Center and reviewing reference material in the files of the Engineering Geology and Rock Mechanics Division and the Technical Information Center. In addition, the following agencies were contacted to determine the availability of information in their files that would be applicable to the study.
 - a. U. S. Army Engineer District, Little Rock
 - b. U. S. Army Engineer District, Fort Worth
 - c. U. S. Geological Survey, Little Rock
 - d. U. S. Department of Agriculture, Little Rock
 - e. Arkansas Geological Commission
 - f. U. S. Army Engineer District, Vicksburg
 - g. U. S. Army Engineer Division, Southwest
 - h. U. S. Army Environmental Hygiene Agency, Aberdeen Proving Ground

- 1. Edgewood Arsenal, Aberdeen Proving Ground
- 1. Southeast Arkansas Planning Commission, Pine Bluff, Arkansas
- k. U. S. Soil Conservation Service, Monticello, Arkansas
- 9. Discussions were held at PBA with members of the Facilities
 Directorate to familiarize WES personnel with prior and ongoing studies
 that might contribute to the current project and a limited reconnaissance
 of the study area was conducted.
- 10. State and Federal offices in Little Rock, Arkansas (listed above) and the U. S. Army Engineer District, Fort Worth, Texas, were visited to review and collect information.

Types of Data

- 11. Personnel of the above named agencies contributed a substantial amount of information consisting of textbooks, regional reports, state surveys, county studies, and several items relating solely to the PBA. The detail of the information varied from exact chemical analysis of soil samples from within the study area to the general, historical accounts of the Mississippi embayment.
- 12. Descriptions of general environmental conditions of the PBA and Jefferson County were available and of reasonable detail. The soils of the PBA were described by the U. S. Department of Agriculture draft reports and portrayed on large scale (1:15,840) aerial photographs. The soils are described from the surface to an approximate depth of 6 ft.
- 13. Useful subsurface information on the PBA was limited. Numerous foundation borings have been drilled but depths are usually less than 20 ft. Several of these borings penetrated a saturated zone but the free water was attributed to a perched water table. Numerous shallow borings have been made to obtain samples from the study area for chemical analysis; all samples have been crushed which prohibited any future engineering test. No descriptive accounts of the strata were maintained and retrieval of any information relative to grain size, permeability, or stratification is impossible. Driller's logs (generalized descriptions) were located for two monitoring wells drilled in the vicinity of the study area; no physical test were performed on any of the samples.

PRELIMINARY

- 14. Climatic data were available in forms of long-term average precipitation records, evaporative maps, and small scale rainfall maps. Precipitation amounts and distributions were available.

 Data review
- 15. The data collected during this study were cursorily reviewed in the order received. This brief review indicated the factor(s) described and their potential usefulness. If the data source contained pertinent information, a bibliographic entry was made and a brief notation made concerning subject matter and scope of investigation. The review was a continuing process requiring a re-review of previously obtained references to check on agreement between different sources of information.
- 16. Upon receipt of available reference material (approximately 80 items), they were placed into groups that related to surface, subsurface, and climatic conditions. Information in each group was then examined to determine which could contribute to the required site descriptions. An attempt was made to select those which covered, in order of priority, the study area, the PBA, Jefferson County, the State of Arkansas, and the Arkansas River Valley.
- 17. Material specifically covering the study site was extremely limited and most studies more broadly addressed PBA or Jefferson County. From these broader studies, the portion of data applicable to the area of interest, either the study area or the PBA was extracted and utilized to prepare the data as presented in Part III, Site Description.
- 18. The reference material identified during the study are presented in two sections—Reference and Bibliography. The Reference Section lists those reports that were used as direct input to the site description. The Bibliography Section lists literature that was identified during the study but not used directly to describe the site.

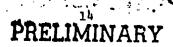
 During the study period, approximately fifty percent of these entries were received and inspected.

PART III: SITE DESCRIPTION

19. While the study concerns the specific area shown on Figure 1, little data were found that pertained exclusively to that area. As a result, the data extracted from the references were used to describe the PBA in terms of the pertinent factors with conclusions given, where possible, as to how these factors influenced the hydrogeology description for the specific site (Figure 1). In most cases, data were available from one or more sources. The data were supplemented by interpretations of aerial photographs of PBA. The descriptions are divided into three categories—surface, subsurface, and rainfall characteristics and each category is described in narrative and graphic form.

Surface Characteristics

20. Landforms within the PBA can be divided into three units, (a) uplands, (b) alluvial terrace, and (c) alluvial plain. The uplands are Tertiary (Jackson group) deposits consisting of unconsolidated sediments (predominantly silts and sandy silts)2,3,4,7 and are characterized by a level to gently rolling surface interrupted by drainage ways of varying sizes. The uplands are bordered by the alluvial terrace and, in some places, by the alluvial plain. The demarcation between the alluvial terrace and the uplands cannot be made on the basis of topography alone-rather, soil types must be relied upon for separating the two. In contrast, an abrupt slope usually forms the boundary between the alluvial terrace and the alluvial plain. Topographically the surface of the alluvial terrace is similar to the uplands in that it is level to gently rolling and is interrupted by streams of varying sizes. The surface of the alluvial terrace is composed of alluvial silts, sandy silts, and clays except in the southern part of PBA where these soils are veneered by loess deposits (aeolian silts). A well defined scarp forms the boundary between the alluvial terrace and the lower lying alluvial plain. The alluvial plain is a relatively flat floodplain



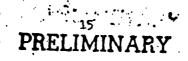
of the Arkansas River and its tributaries. This surface is characterized by meander belt deposits consisting of abandoned channels, natural levee, backswamp, and point-bar deposits. The surface soils range from clays, silts, to silty sands depending upon the environment of deposition. The landforms are graphically portrayed in Figure 2 and the occurrence of surface soil types are shown on Plate 1.

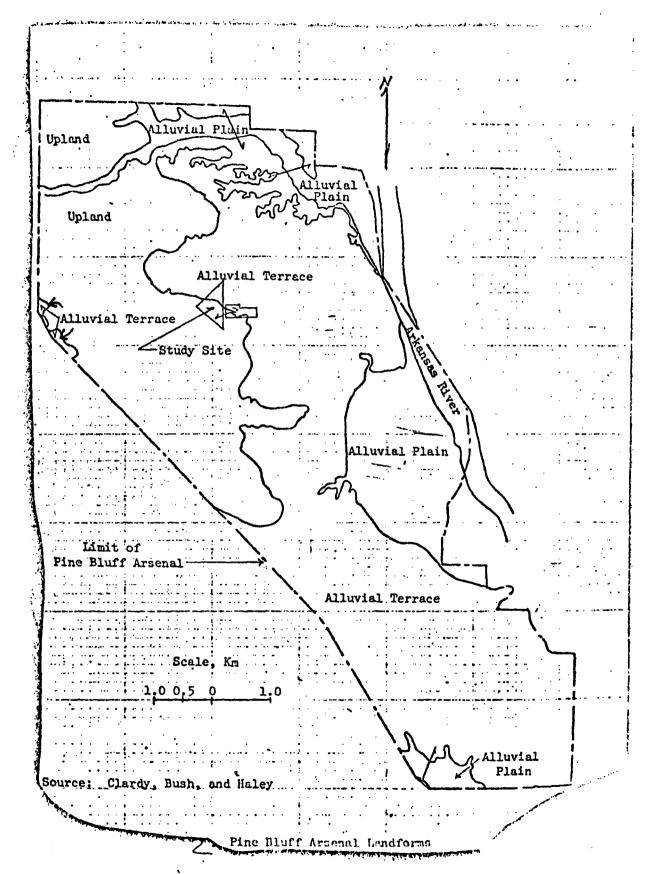
21. As shown in Figure 2, the boundary between the uplands and the alluvial terrace, almost bisects the site. However, while Plate 1 shows the surface soils at the site to consist of low plasticity silts (ML*) and silty sands (SM*), silty sands predominate suggesting that the surface is free of a loess veneer. It should be re-emphasized here that the data from which these conclusions are reached result from generalized data obtained from the literature and not from on-site sampling and required laboratory testing and classification. The inferrence is that rainwater is relatively free to infiltrate through the surface soils at the study site. This free draining state is highly modified by the existence of hardpans over much of the PBA.

22. Slopes are very gentle over most of the PBA. In many places, they are less than one percent and seldom exceed three percent.

Blopes of the escarpment between the uplands and the alluvial plain are greater than 100 percent, but the aerial extent is limited. Slopes bordering the drainage ways sometimes approach or exceed 12 percent, but again, these are of limited areal extent. Surface drainage is well developed and nearly all areas of the developed portions of the PBA are well drained. Slopes generally associated with specific soil types (as shown on Plate 1) provided the basis for the slope map shown on Plate 2. Examination of topographic maps generally confirm the slopes as presented. Ravines and stream channels usually produce slopes greater than those shown on Plate 2 necessitating further treatment on a final, large-scale project map. As shown on Plate 2 the eastern part of the site should have slopes ranging from 1 to 3 percent; the western part of the site

Designations from United Soil Classification System



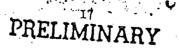


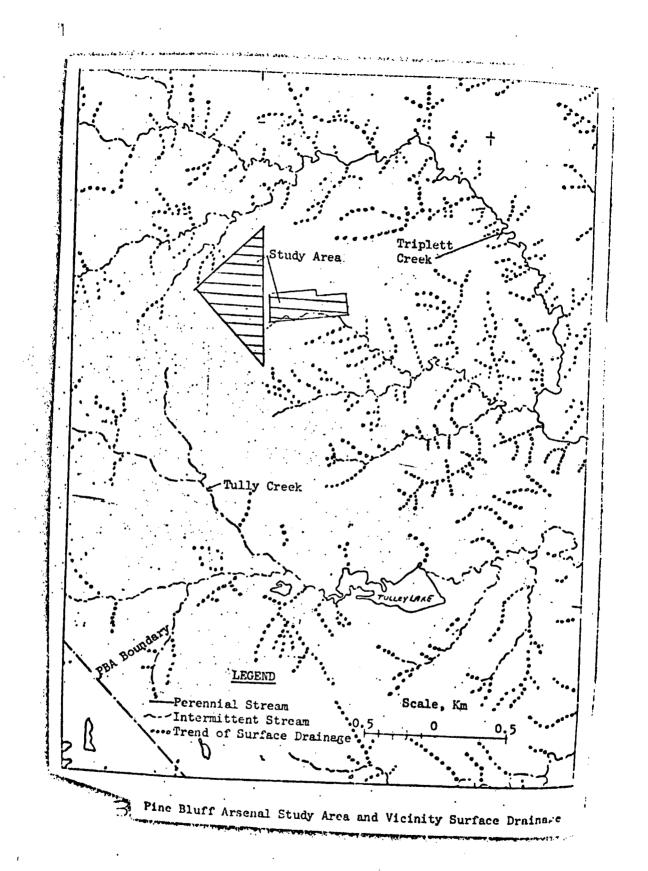
should have slopes ranging from 3 to 8 percent. Such information is important to site assessment in that the slope indicates whether rainfall would tend to leave the area as surface runoff (steep slopes) or infiltrate (shallow slopes). However, the study indicated that drainage of the uplands and the alluvial terrace at PBA is principally in the form of surface runoff and not infiltration.

- 23. The lower lying alluvial plain is frequently flooded and is characterized by an extremely shallow water table. The alluvial terrace and uplands surfaces are drained by a series of permanent and ephemeral streams and drainage ways. For example, in a general review, VTN Louisiana, Inc. 6 considered the entire PBA as belonging to the Arkansas River Basin drainage system. In a more detailed study, an Edgewood Arsenal report subdivided the PBA into eight sub-basins of drainage. Figure 3 shows the surface drainage in the vicinity of the study area. Precipitation on the study area constributes runoff to two of the eight sub-basins which are drained by Triplett and Tulley Creeks.
- basins which are drained by Triplett and Tulley Creeks. CREEK IN FIG. 1
 24. Land use affects surface runoff and infiltration. An examination of data for the entire PBA shows the usual land uses associated with a reservation of this type, i.e. production areas, storage areas, recreational areas, woodlands, etc., but the immediate site is in an abandoned state with no organized use. For this reason no land use map was prepared.

Subsurface Characteristics

- 25. The subsurface characteristics are discussed in terms of soil types, permeability, and groundwater conditions. The referenced data on soil types and permeability dealt only with materials found in the top 6 ft of the subsurface; no data exists for deeper materials.
- 26. The subsurface soils of the uplands are similar to the surface soils in that they are predominantly silts, but with increasing amounts of clay with depth. The subsurface soils of the alluvial terraces



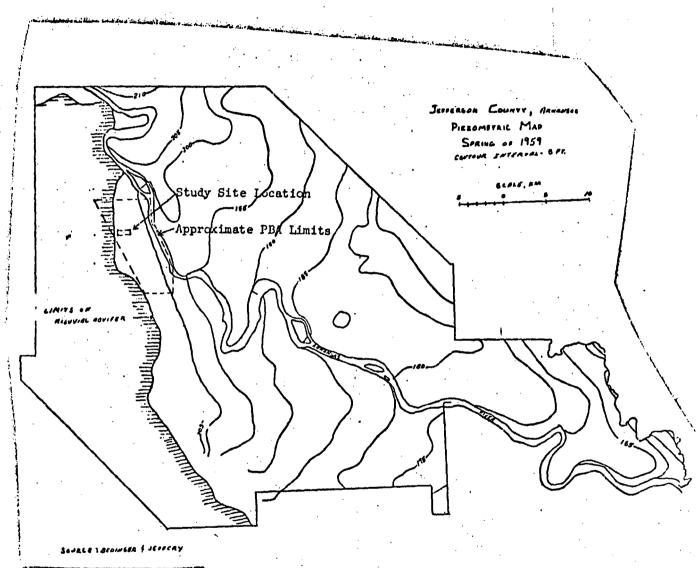


are predominantly silts and clays for varying depths and are underlain by coarser material. The depth to and type of material underlying the alluvial plain depends upon the environment of deposition. Practically all types of material (sand, clay, silt, and gravels) can be encountered at some depth in the subsurface of the alluvial plain although according to data collected for the top 6 ft within the limits of the PBA it is principally silts, sandy silts, and clays. The loess areas on the terrace are characterized by a relative homogenous silt in the subsurface; however these deposits have developed distict fragipan layers which are conducive to a perched water table during periods of prolonged or heavy rainfall. Plate 3 identifies the subsurface soil types within the limits of the reservation. As shown, the immediate subsurface materials at the study site consists predominantly of inforganic, low plasticity clay and subordinately of silt or sandy/clayey silt.

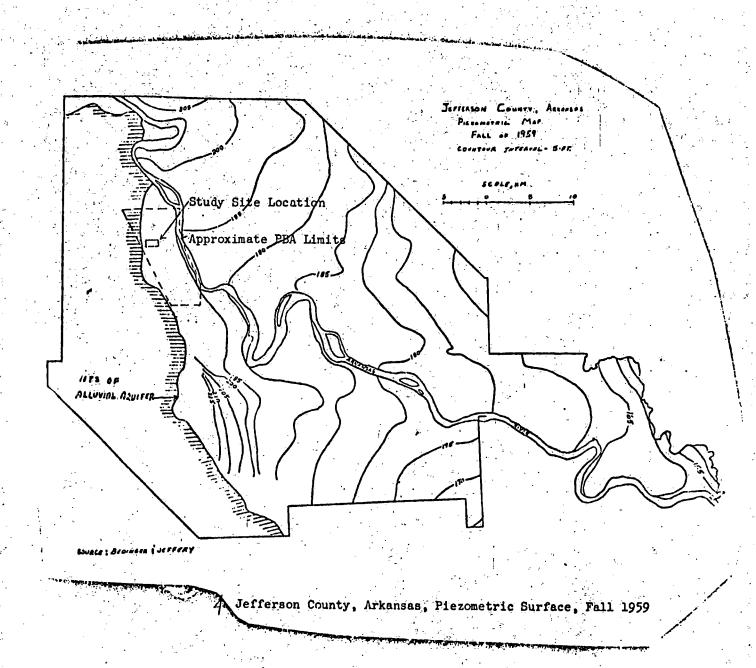
27. Average permeability values derived from U. S. Department of Agriculture studies 2 are low, suggesting that only small amounts of rainfall percolate through the upper soils to groundwater. No estimates of infiltration values were made by these studies and no other data on infiltration were located during this study except for a spraying test. The spraying test was conducted for disposal of water on an area of Caddo-Pheba-Savannah soil association (surface soil ML, subsurface type ML. i.e. typical of the uplands found on the western part of the study site, reported permeability of 0.2 to 0.6 in./hr). A spraying rate of 0.09 in./hr exceeded the capacity of the soil to accept that volume of water by infiltration; as a result subsequent surface runoff occurred. While some infiltration occurred, test data were available for only the upper 12 in. The inadequacy of the soil to internally drain the volume of water being sprayed could have been caused by the high loading rate or a fragipan with a permeability much less than that reported for the general soil profile. The permeabilities shown on Plate 4 reflect the minimum values as indicated by the USDA² for any portion of the upper 6 ft of soil. At the study site permeabilities varying from 0.2 to 0.6 in/hr are indicated. Such values are high and indicate near free draining soil but hardpans usually modify these conditions.

- 28. Groundwater for the purposes of this report, is defined as the highest elevation of the saturated zone or water table. It is probable that this definition includes three different zones or elevation ranges within the confines of the PBA. Two of these zones may be of little consequence from the standpoint of being contaminated from surface infiltration. These zones are the occasional perched water table resulting from a shallow fragipan or hardpan and extended periods of rainfall and the artesian aquifer in the Sparta formation which underlies the Jackson group. While the Sparta is more than 600 ft below the surface, the artesian pressure raises the piezometric surface to about 100 ft below the site. The third zone, commonly referred to as the alluvial aquifer, is of primary concern for pollution potential. The alluvial aquifer underlies only the alluvial terrace and the alluvium plain.
- 29. Although the alluvial aquifer has not been investigated in detail at the PBA, some U. S. Geological Survey studies 9,10 have included portions of the PBA. The water monitoring study 11 initiated in 1967 required that 15 wells be completed to the alluvial aquifer. Two of these wells were located east of the study area and encountered water at a depth of 50 ft or an approximate elevation of 190 ft msl. The remainder of the wells were located in the southwest sector of the reservation and exhibited water level observations of approximately 195 ft msl. An earlier study presenting groundwater conditions in the Lower Arkansas River Valley indicated similar ranges in elevations for the groundwater surface. Portions of the piezometric maps presented in the earlier study are given in Figure 4 and 5 for the spring and fall 1959 conditions, respectively. These figures indicate the groundwater elevation at the study site should be expected to vary from about 195 to 200 ft msl.
- 30. No recent, alluvial groundwater elevations have been obtained within the PBA, but there is little reason to expect radical elevation changes. The nearness to the Arkansas River and the remoteness from heavy pumpage would suggest that the groundwater elevations are reasonably stable. Channel improvements in the Arkansas River have

PRELIMINARY



Jefferson County, Arkansas, Piezometric Surface, Spring 1959



probably even reduced the possibility of fluctuations attributed to river stage variation. As apparent from Figures 4 and 5, the river was acting as a drain on the aquifer when the piezometric maps were made. It was suggested in recent conversations with U. S. Geological Survey personnel in Little Rock that the channel improvements resulting in a minimum pool elevation of 196 ft msl may create a constant recharge situation. An evaluation of this probability should be part of the future study.

- 31. The saturated zone extends from the water table through the alluvial deposits to the top of the Jackson. Generally, the alluvium in the floodplain ranges in thickness from 76 to 195 ft with averages of approximately 100 ft thick. The bottom of the aquifer is the contact with the underlying Tertiary clays of the Jackson-Claiborne groups. These clays underlie the alluvium at an approximate elevation of 160 ft msl at Lock and Dam 5 on the Arkansas River north of the PBA and at an approximate elevation of 90 ft msl at Lock and Dam 4 south of the PBA. Some logs 10 show this group to be at an approximate elevation of 110 ft msl in the vicinity of the reservation. This Tertiary surface rises rapidly to the west and outcrops in the westward portion of the reservation.
- 32. The alluvial terraces (Quaternary) on the PBA are underlain by Tertiary deposits at elevations ranging from 250 ft msl (average outcrop contour) to confirmed elevations of 160 to 170 ft msl. The elevation of the water table in the terraces was determined to be approximately 195 ft msl. These data indicated that the alluvial aquifer thickness would range from 0 ft in the western portion of the reservation to some 80 to 90 ft in the alluvium adjoining the River. No reliable estimates of north-south variation are possible, but with the approximate constant elevation of the Quaternary surface and the decreasing elevation of the Tertiary surface with constant water table elevation, it is expected that the thickness of the saturated zone would increase to the south as well as to the east.

33. Paleozoic bedrock lies about 3000 ft below the surface and exhibits no known or hypothesized effects on the groundwater regime of the reservation.

Rainfall

34. Precipitation at PBA averages about 50 in. per year. The distribution is reasonably uniform with the fall months receiving less than 4 in. and the winter and spring months receiving 4 to 6 in. of rain. The precipitation is primarily rainfall as less than 2 in. per year of snow are usually recorded. Potential evaporation is approximately 58 in. per year but actual evaporation of course depends upon ambient conditions and rainfall. Infiltration is dependent upon runoff and evaporation (including transpiration) but no quantitative figures were found. A graphic display of rainfall during two specific years, 1958 and 1959, at Pine Bluff are shown in Figure 6, and Table 1 presents monthly averages during the period of 1941-1970.

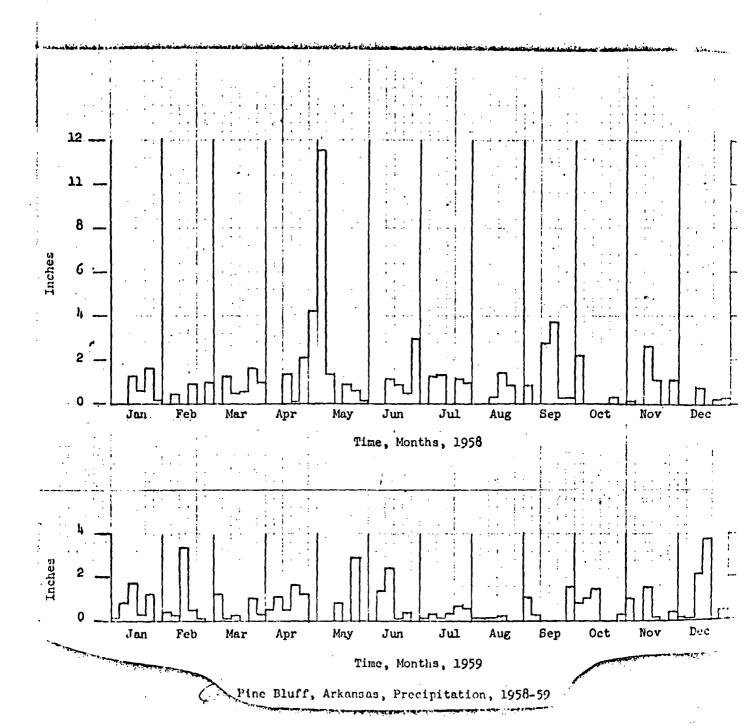


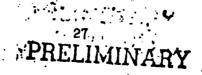
Table 1. Average Precipitation at Pine Bluff, Arkansas, 1941-1970

		Precipitation, Inches
, ,		
	January	4,47
	February	4.79
		5.41
	March	1
•	April	5.65
٠.	May	5.51
SHE	June	2.85
MON	July	
· ·	OULY	3.57
· .	August	3.14
	September	3.60
*	October	3.23
•	· November	4.00
	December	4.5 0
	the state of the s	the state of the s

Source: U. S. Department of Commerce, 1973

Conclusions

- 35. A considerable amount of data is available which is applicable to the definition of pollutant migration potential. These data have been generated by the PBA, the USGS, the Arkansas Geological Commission (AGC), and the U. S. Army Engineer Districts, Fort Worth, Little Rock, and Vicksburg.
- 36. The U. S. Army Engineer Districts (Fort Worth, Little Rock, and Vicksburg) have conducted or sponsored work associated with foundation investigations, floodplain planning, and environmental inventories. The exploratory boring and floodplain planning have contributed to the assessment of shallow, subsurface conditions while a later study, conducted by VTN Louisiana, Inc. was a comprehensive survey of countywide conditions. The design and construction of two lock and dam systems on the bordering Arkansas River furnished valuable information on floodplain soils, geology, and groundwater depths.
- 37. The AGC work is primarily state oriented, but these portions applicable to the PBA and adjacent terrain are extractable and useful. Their collection of water well boring logs furnish substantial information on the surrounding county. A few specific county-oriented studies are available.
- 38. The USGS has monitored water levels in the Arkansas River Valley for an extended period of time. Information from these sources are valuable for predicting long-term trends and the boring logs are especially valuable for defining subsurface conditions.
- 39. The PBA has conducted several studies relative to the pollution migration potential. The study by Lachapelle, Brooks, and Trescott presents a firm foundation on which to build future studies. The studies currently being conducted have a potential for substantially contributing to the knowledge of the subsurface. The latest study by Pinkham, Pearson, Fuller, and Bender presents an overview of the PBA environment and



furnishes a "first look" which is valuable in the initiation of programs to furnish detailed analysis.

Recommendations

- 40. A definite need exists for subsurface evaluation of both the saturated zone and zone of aeration over most of the PBA. The immediate concern is the subsurface soil and groundwater conditions underlying the study area as presented in Figure 1. Onsite drilling and appropriate sampling procedures will define strata characteristics and the installation of various types of post-drilling sampling equipment will permit monitoring of pollutant movement in the zone of aeration and the development of mathematical models to predict any long-term migration trends.
- 41. The saturated zone will have to be defined for the immediate site as well as the adjacent areas of the PBA in order to predict any movement within this zone. Piezometric surfaces need to be defined in terms of elevation, gradient, and movement. The saturated zone should be investigated to determine if stratification of movement occurs and if a dilution/distance relationship exists. Samples taken at existing well locations during drilling operations, and subsequent to drilling will permit definition of movement and possible mathematical modeling.
- 42. The program to accomplish these recommendations is presented in Appendix A.

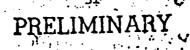
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Background

- Al. A work statement, dated 1 October 1975, entitled "Soil Survey Work at Pine Bluff Arsenal" was prepared and submitted by the USAE Waterways Experiment Station (WES). Subsequent meetings between personnel of the Pine Bluff Arsenal (PBA), WES, and the Chemical Demilitarization and Installation Restoration staff of the Army Materiel Command resulted in an understanding of the scope of work to be accomplished by the study described by the work statement and the submission of "Justification of the FY 1977 Budget Request for Geologic/Hydrologic Studies at Pine Bluff Arsenal" on 11 November 1975.
- A2. The latter document divided the study at the PBA site into three major parts: (Task I) Site Investigation, (Task II) Site Assessment, and (Task III) Site Monitoring. Task I was further subdivided into three phases: (A) Office study, (B) Field investigation, and (C) Laboratory testing. The first phase consisted of three efforts: (1) a literature survey, (2) a review of literature and compilation of preliminary site maps, and (3) formulation of a definitive plan of action. The efforts in phase (A) (Office study) of Task (I) were completed and described in this report. The results of the literature survey and review of literature and compilation of preliminary site maps were used to refine the preliminary plan of action, as originally described in the 11 November 1975 justification.

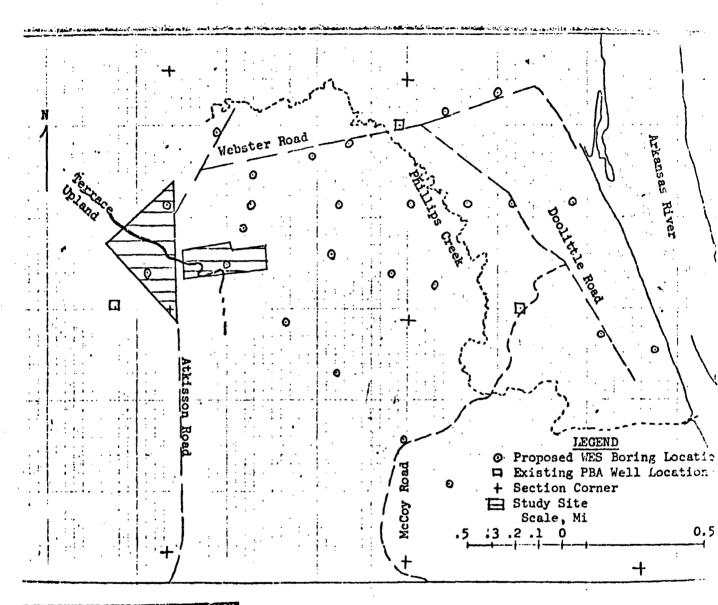
Plan of Action

A3. Further studies at the PBA will be initiated with phase (B) (Field investigations) of Task (I) (Site Investigation). While the remaining work at the PBA as presented in the above cited document of 11 November 1975 appears to fully justified on the basis of the completed portions of the work, it is recommended that the magnitude of the subsurface exploration and subsequent laboratory testing be expanded due to

subtleties expected to occur in subsurface conditions. Figure Al shows the locations of borings currently thought necessary for defining the subsurface conditions at the study site. These boring locations were selected to adequately define the substrata and the piezometric surface of that portion of the PBA lying between the study area and the Arkansas River. This area was isolated for detailed analysis for the following reasons:

- a. The geologic boundary between shallow aquifer in the terrace materials and the essentially dry formations to the west, which almost bisects the study area in a generally east-west direction, must be defined.
- <u>b</u>. The selected sector encompasses the shortest distance to a major water body, the Arkansas River.
- c. The sector covers all logical groundwater paths extending from the site.
- d. Existing PBA data will supplement subsequent piezometric determinations.
- e. The borings should permit delineation of any effects that the perennial stream, Phillips Creek, has on the water table.

A4. This tentative number of borings has resulted in an increase in the proposed budget due to increased drilling cost and laboratory testing. Similarly, the time requirements have been adjusted. The plan of action presented in the following pages reflect these changes to the document submitted on 11 November 1975.



PBA Study Site and Vicinity Showing Proposed Boring Locations

All

Task I: Site Investigation

Phase Λ: Office Study - (Completed and described in this report)

Effort 1. Site reconnaissance. Collect appropriate on-site data to refine preliminary maps.

- a. Surface soil samples
- b. Slope and drainage data
- c. Physical description of area of interest
- d. Land use
- e. Water level data on existing wells
- f. Interview personnel for waste generation, dates of disposal, disposal procedures, etc.

This effort will provide data to validate or refine the preliminary site maps and provide the basis to verify the plan for subsurface exploration as detailed below.

Effort 2. Subsurface exploration

- a. Preliminary
 - (1) Refine boring locations and depths
 - (2) Verify type of sampling and frequency, and identify other types of exploration such as refraction seismic, vibratory, geophysical logging, and fluid sampling that might be applicable.
- b. Conduct field exploration
 - (1) Drill necessary borings and prepare detailed boring logs.
 - (2) Obtain samples (soil and water)
 - (3) Installation of piezometers or lysimeters, as necessary
 - (4) Perform pumping tests for field permeability, as necessary.
- A5. The subsurface exploration will be conducted using a WES drill crew which is proficient in the art of subsurface sampling or using PBA equipment with WES supervision. All WES drilling and sampling equipment,

tubing, and equipment for preparing and preserving samples, etc., will be available for almost any conceivable condition. The installation of piezometers or lysimeters will be based on the field data collected. The cost estimate, shown later, assumes subsurface exploration will be conducted by a WES drill crew.

Phase C: Laboratory testing

Effort 1. Physical tests of soil

- a. Density
- b. Water content
- c. Classification
- d. Clay mineralogy
- A6. All samples obtained will be carefully preserved and crated for shipment. The above tests are the minimum effort necessary to obtain recommended physical properties to provide necessary detail for site evaluation and assessment. Other tests may be included to complete the site description, but is not included in the bost estimate.
- Effort 2. Tests for contaminants. It is assumed that all chemical/pesticide tests will be conducted by PBA equipment/personnel. However, if desired by PBA, WES will be willing to suggest appropriate tests based upon previous and ongoing work. In preparing the cost estimate no allowance is shown for WES to conduct tests for contaminants.
- A7. Upon the completion of Task I, all data pertaining to the subsurface hydrogeology conditions (in terms of descriptions of strata and their physical properties, contaminants present and their concentration and position) will have been collected. Additionally, suitable instruments will have been installed to provide for the monitoring of long-range effects and to verify the results of the assessment task.

Task II: Site Assessment

A8. Once data have been collected, evaluated, and placed into proper format, the boundary-value problem can be described. Such description will include depth, thickness, uniformity, extent, permeability

Effort 3. Obtain predictions. Based on PRA input, future site activities will be described and used as input to the model to predict future effects of engineering activities of the site.

Task III: Site Monitoring

Alo. Once the site data have been collected, synthesized, and cast into a form to properly calibrate the geological/hydrological model, the predictions resulting therefrom exhaust the possibilities in terms of analytical capabilities at the present time. Predictions of future changes must be verified. If subsequently collected data are deemed to be in substantial disagreement with predictions, the model must be further refined. However, to substantiate predictions, a sampling program of both soil/water samples must be established. In either case, the assaying of samples (whether soil or water) can be handled with present PBA capabilities. At this stage it is necessary to mention that the plan of action recognizes that site monitoring will be required. It is likewise recognized that borings made during the subsurface exploration can be subordinately used to obtain water quality samples. Subsurface samples of soil for subsequent contaminant assessment will have to be obtained from additional borings specifically for that purpose. It is envisioned here that both subsurface soil and water samples can be obtained by PBA equipment and personnel. Similarly, it is assumed that assaying of the samples can be made by PBA personnel.

All. Personnel of WES will be available to aid in site monitoring activities as requested on a cost reimbursable basis. In any event, such activities are not envisioned as part of FY 77 requirements and are not included in the cost/time estimate in the following paragraphs.

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APPENDIX H

BUILDING INVENTORY
PINE BLUFF ARSENAL

BUILDING INVENTORY PINE BLUFF ARSENAL

•	Building Number	Description	Building Number	Description
	Non-Industr	<u>ial</u>		
	42900	Ammunition Demil Facility	60440	Loading - Unloading Docks
	55000	Other	60520	Other
	55020	Administrative	60610	General Purpose Warehouse
	55030	Other	60620	deneral lurpose warenouse
<i>:</i> .	55040	Other	60630	
	55050	Other	60640	
	550 6 0	Sentry Station	60650	· · · · · · · · · · · · · · · · · · ·
	55061	Septic Tank Drainage Field	60660	General Purpose Warehouse
	55110	General Purpose Warehouse	60710	
	55115	General Purpose Warehouse	60720	High Explosive Magazine
	55220	Other	60730	High Explosive Magazine
	55320	Other	60740	High Explosive Magazine
.7	55330	Septic Tank Drainage Field	61010	High Explosive Magazine
4, 5	55410	General Purpose Warehouse		Smokeless PO Magazine
	55415	General Purpose Warehouse	61020	Fallout Shelter
	60060	General Purpose Warehouse	61030	Smokeless PO Magazine
	60070	Other	610 40	
. •	60080	Sewage Pump	61050	1
s ²	60090	Administrative	61060	
	60100	Inflamable Material Storehouse	61070	
	60320	Loading - Unloading Docks	61080	
	60340	Loading - Unloading Docks:	61090	
	60400	Other	61100	
	60401	Lumber Shed	61110	
٠٠.	60402	Lumber Shed	61120	
	60420	Loading - Unloading Docks	61130	
4	00720	Loading - ourodding bocks	61140	Smokeless PO Magazine

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61330	High Explosive Magazine		61650	High Explosive Magazine	
61340	High Explosive Magazine		61660	High Explosive Magazine	
61350	High Explosive Magazine		61670	High Explosive Magazine	•
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	61840	Fuse Detonator Magazine		62160	Smokeless PO Magazine	
	61850	· ·		62170	High Explosive Magazine	•
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	61980	High Explosive Magazine		62300		
	61990	High Explosive Magazine		62310		
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	62020	Smokeless PO Magazine		62340	Fuse Detonator Magazine	
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	62450	High Explosive Magazine	62770		
•	62460	Fuse Detonator Magazine	62780		
	62470	Fuse Detonator Magazine	62790		
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	62490	Fuse Detonator Magazine	62810		
	62500	High Explosive Magazine	62820		
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	62740	High Explosive Magazine	631 1 0	Ammunition Renv Shop	

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		(Wilder	beset (peron
63120	Smokeless PO Magazine	10030	Cafeteria
63200		10040	Telephone Exchange
63210		10050	Fire Station
63220	}	10075	Golf Club House
63230		10210	Flagpole
63300	į	11010	Vacant
63310	1	11020	Sentry Station
63320	V	11030	Vacant
63410	Smokeless PO Magazine	11050	Vacant
64010	High Explosive Magazine	12300	Family Housing
64020	Vacant	12302	
64100	Loading - Unloading Docks	12304	·
81100	General Storehouse	12306	
81200		12308	j
81210	· ·	12310	♥
81300		12312	Family Housing
81310		12415	Septic Tank Drainage Field
81330		12510	Public Toilet
81400		12550	Other
81410		12560	Other
81420		12600	Rod and Gun Club
81430		130 00	Elevated Water Storage Tank
81510		13010	Administrative
81520	·	13020	Administrative
81530	•	13030	Administrative
81600		13040	Dispensary
81610	•	130 5 0	Dispensary
81620	General Storehouse	13060	Credit Union
		13080	Laboratory
<u>ndustrial</u>		13090	General Installation
10000		13100	Other
10020	Post Headquarters	13110	General Storehouse

Building Number	Description	Building Number	Description
13120	Steam Plant Power	16060	Theater
13700	Family Housing	16075	Outdoor Swimming Pool
13701	1	16110	Vacant
13702		16150	General Storehouse
13703		16210	Enlisted Housing
13704		16220	Enlisted Housing
13705		16230	Other
13706		16250	General Storehouse
13707		16360	EM Service Club
13708	♥	16270	Enlisted Personnel Mess
13709	Family Housing	13610	Recreation Building
14013	Water Pump NP	16340	Exchange Branch
14014	Water Pump NP	16420	Gas Station
14020	Medical Cal Pro Ldg	16430	Auto Self Help Garage
15011	Det Strength	16450	Other
15012		16490	General Purpose Magazine
15022		16500	Kenne 1
15031		17050	Sewage Pump
15042		17996	Other
15051		22600	Scale House
15062		23100	Sub Station
15071	\	2331 0	General Purpose Warehouse
15082		23330	General Purpose Warehouse
15091		23350	General Purpose Warehouse
15092	Det Strength	23370	Administrative
15103	General Storehouse	23390	General Purpose Warehouse
15210	Open Mess, Officer	23421	Inflamable Material Storehouse
15215	Outdoor Swimming Pool	23422	Inflamable Material Storehouse
15330	BOQ	23445	Lumber Shed
15350	BOQ	23450	Lumber Shed
16020	Open Mess, Noncommissioned Officer	24010	Sentry Station
16040	Signal Field Maintenance Shop	24020	Sentry Station

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Building		Bui 1ding	·	
Number	Description	Number	Description	
24030	Sentry Station	31630	Other	
24500	Other	31631	Other	
24550	Sewage Pump	31632	Other	
24610	General Purpose Warehouse	31640	Other	
24761	Vacant	31650	General Storehouse	
24770	General Purpose Warehouse	31670	Other	
31010	Vacant	31672	Vacant	
31013	Water Pump NP	31710	Fuse Detonator Magazine	
31014	Water Pump NP	31720	Other	
31015	Water Pump NP	31730	Other	
31060	Steam Plant Power	31731	Other	
31080	General Purpose Warehouse	317 4 0		
31100	Vacant	31750	Fuse Detonator Magazine Other	
31150	Vacant	31810		
21210	General Purpose Warehouse	31820	Fuse Detonator Magazine Other	
± 31230	General Purpose Warehouse	31830		
31250	General Purpose Warehouse	31840	Other Datas Assault	
31270	General Purpose Warehouse	31850	Fuse Detonator Magazine	
31310	Inflamable Material Storehouse	31860	Vacant	
31330	Inflamable Material Storehouse	31870	Other	
31420	Inflamable Material Storehouse		Vacant	
31435	Other	320 00 3 20 70	Vacant	
31440	Inflamable Material Storehouse	320 FB	Sentry Station	
31530	Other	32013	No Current Description	
31530	Other		Water Pump NP	
31531	Other	32014	Water Pump NP	
31532	Vacant	32030	Motor Repair Shop	
31540	Other	32035	Motor Repair Shop	
31550	General Storehouse	32050	Gas Station	
31570	Other	32060	Steam Plant Power	
		32070	Other	
31572 31620	Vacant	32080	FE Maintenance Shop	
31020	Other	32090	General Purpose Warehouse	

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	Building		Building	
	Number	Description	Number	Description
	32091	Inflamable Material Storehouse	32640	Other
	32100	Vacant	32650	Other Other
	32130	Other	32670	
,	32131	Other	32690	Other
•	32150	Administrative	32710	Other
	32210	General Purpose Warehouse	32720	Fuse Detonator Magazine
	32230	General Purpose Warehouse	327 30	Other
	32250	General Purpose Warehouse	327 4 0	Fuse Detonator Magazine
· .	32270	General Purpose Warehouse	32750	Fuse Detonator Magazine FE Maintenance Shop
•	32310	Inflamable Material Storehouse	32750 32810	
	32330	Inflamable Material Storehouse	32820	Fuse Detonator Magazine Other
	.32335	Other	328 3 0	Other Other
	32420	Inflamable Material Storehouse	32840	· · · · · · · · · · · · · · · · · · ·
•	32440	Inflamable Material Storehouse	328 5 0	Fuse Detonator Magazine Other
	32480	Transit Shed	32860	Other
H-9	32510	Other	32870	• Other
9	32520	Other	32880	Vacant
	32530	Other	33000	vacant Cafeteria
	32532	Other	33010 33010	
	32534	Vacant	33013	Sentry Station
	32535	Other	33013 33014	Water Pump NP
	32536	1	3301 5	Water Pump NP
	32538		33060	Water Pump NP
,	32540		33080	Steam Plant Power Other
	32550	·	33100	
•	32570	•	33150 33150	Change House
	32572		33210	Vacant
	32610	· ·		General Purpose Warehouse
	32620		33230 33250	General Purpose Warehouse
	32630	Other	33270	General Purpose Warehouse
	32631	Vacant		General Purpose Warehouse
	32632	Vacant	33310 33320	Inflamable Material Storehouse
		· www.i v	33320	Vacant

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	Building Number	De	escription	Building Number	Description	
	33330	. Ir	nflamable Material Storehouse	33860	Other	•
	33420	Ir	nflamable Material Storehouse	33870	Other	
	33440	Ir	nflamable Material Storehouse	33910	Other	· • • • • • • • • • • • • • • • • • • •
	33480	Tì	ransit Shed	34001	Vacant	
•	33520	01	ther	34010	Water Pump NP	
	33525	0	ther	34011	Vacant	
	33530		ther	34012		
	33531	01	ther	34013	. .	
	33532	St	torage	34014		•
	33540		ther	34015		
	33550	*		34016	•	
	33570			34017		
	33572	•.		34021		•
	33620		\dot	34022		
•	33630	01	ther	34023		•
	33631	٧a	acant	34024		
	33632	01	ther	34025		·
	33640	01	ther	34026		
	33650	0	ther	34027		
	33670	0	ther	34031		
	33672	0	ther	34032		
	33710	Fi	use Detonator Magazine	34033		
	33720	0	ther	34034		
	33730	Va	acant	34035		•
	33740	Fi	use Detonator Magazine	34036		• ••
	33750		ther	34037		
	33760	0	ther	34042		
	33810	Fi	use Detonator Magazine	34044		+ 2 · · · · · · · · · · · · · · · · · ·
	33820	0	ther	34046		•
	33830	01	ther	34051		• .
	33840	01	ther	34052	♦	L.*
	33850	٧a	acant	34053	Vacant	
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	Building	•.		Building		
•	Number	Description		Number	Description	-
	34054	Vacant		34112	Inflamable Material Storehouse	
	34055	1		34115	Medical Cal Pro Ldg	
	34056			34117	Inflamable Material Storehouse	
•	34057			34118	Other	•
•	34061		•	34120	Change House	
	34063			34130		•
	34065			34133 34133	Medical Cal Pro Ldg	
	34067			34133 24135	Medical Cal Pro Ldg	
	34071			34135	Medical Cal Pro Ldg	
•	34072			34140	Steam Plant Power	-
	34073		•	34160	Cafeteria	
	34074			34170	Medical Cal Pro Ldg	
. • •		· ·		34220	General Purpose Warehouse	
	34075	ł · · · · ·		34250	General Purpose Warehouse	
	34076			34310	Vacant	
干	34077	1		34350	Other	
: _	34081			34360	Other	
–	34082			34380	Fuse Detonator Magazine	
	34083	1		34430	General Purpose Warehouse	
,	34084	1	•	34440	General Purpose Warehouse	
	34085	j		34450	General Purpose Warehouse	•
A . *	34086	1		34460	General Purpose Warehouse	,
	34087		•	34630	Other	
•	34091			34640	Other	
	34092			34650	Other	•
	34093	l		34660		ů.
.*	34094		1		Other	
	34095			34680	Vacant	
	34096	•	•	34820	Other	.,
	34097	Vacant		34860	Fuse Detonator Magazine	,
	34101	Sentry Station		34909	Grease Racks	
	34110	Modical Cal Dec	l da	34910	FE Maintenance Shop	
•		Medical Cal Pro	rag	34911	Other	
	34111	Other		34913	General Storehouse	
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		Building		Building	
		Number	Description	Number	Description
					30001194101
-		34914	Gas Station	41320	Fuse Detonator Magazine
		34930	FE Maintenance Shop	41330	1
		34940	Sentry Station	41340	
		34960	FE Maintenance Shop	41350	
		34961	FE Facilities	41360	
		34970	Administrative	41370	
		40010	Sentry Station	41380	
		40011	Public Toilet	41410	·
		41010	Fuse Detonator Magazine	41420	
		41020	Fuse Detonator Magazine	41430	
		41030 41040	Fuse Detonator Magazine	41440	
		41050	Other General Purpose Warehouse	41 450	
		41060		41460	
	•	41070	Fuse Detonator Magazine	41470	
	Н-12	41080		41480	
	12	41110	·	41510	
	•	41120		41520	
		41130		41530	
		41150	₽	41540	
		41160	Fuse Detonator Magazine	41550 41560	
	•	41170	Other	41570	
		41180	Fuse Detonator Magazine	41580	
		41210		41610	
		41220		41620	
		41230		41630	
		41240		41640	
-		41250		41650	
		41260		41660	
		41270		41670	
		41280	₩.	41680	\rightarrow
	٠.	41310	Fuse Detonator Magazine	41710	Fuse Detonator Magazine
		•			
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Building Number	Description	Building Number	Description
41720	Fuse Detonator Magazine	42822	Sewage Treatment Plant
41730	1	43000	Elevated Water Storage Tank
41740		44100	Cafeteria
41750	·	44101	Sentry Station
41760		44102	Sentry Station
41770		44110	Medical Cal Pro Ldg
41780		44120	Steam Plant Power
41810		44200	Sewage Pump
41820		44212	Other
41830		44213	i i
41840		44214	
41850		44215	
41860		44219	•
41870	. ♦	44220	Other
41880	Fuse Detonator Magazine	44300	Administrative
42000	Elevated Water Storage Tank	44301	Other
42010	Water Well with PS	44302	Septic Tank Drainage Field
42013	Water Pump NP	50020	General Purpose Warehouse
42020	Water Well with PS	50040	General Purpose Warehouse
42030	Water Well with PS	50060	General Purpose Warehouse
42200	Water Treatment Plant	50080	General Purpose Warehouse
42210	Water Treatment Plant	501 00	Sub Station
42212	Fuel Storage Tank	50110	General Purpose Warehouse
42213	Water Treatment Plant	50120	1
42215	Water Treatment Plant	50130	
42216	Water Treatment Plant	50140	•
42225	Septic Tank Drainage Field	50150	}
42300	Incinerator	50160	1
42410	Vacant	50170	
42600	Sewage Pump	50180	General Purpose Warehouse
42750	Sewage Treatment Plant	50190	Water Well with PS
42820	Sewage Pump	50220	General Purpose Warehouse

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Building Number	Description	Building Number	Description
50230	General Purpose Warehouse	53600	Vacant
50240	1	53890	Vacant
50250	1	53900	Vacant
50270		53910	Other
5 0290		53990	Other
50310		53991	Other
50340	l ·	54010	
50360			General Purpose Warehouse
50410		54110 54120	General Purpose Warehouse
50430		54130	Vacant
50510		54131	Vacant
50610 50610		54140	Vacant
50810	<u>l</u>	54141	Vacant
50910	Consum I Dimenso Havebause	54150	Vacant
	General Purpose Warehouse	54151	Other
51190	Water Pump NP	54160	Vacant
51420	Divisional Headquarters	54161	Vacant
51570	RR Equipment Maintenance Shop	54180	Elevated Water Tank NP
51630	Motor Repair Shop	54190	No Current Description
51650	Diesel Station	54240	Vacant .
53013	Water Pump NP	54241	
53100	Other	542 6 1	
53150	Vacant	542 62	
53180	No Current Description	54270	
53220	Vacant	54280	
53221	Vacant	54290	
53225	Vacant	54291	
53250	Vacant	54292	
53300	Fuel Storage Tank	54293	
53301	Fuel Storage Tank	54300	
53321	Vacant	54310	
53350	Vacant	54325	<u>.</u>
53450	Vacant	54340	Vacant

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	Building Number	Description	Building Number	Description
	54341	Vacant	54000	
	54350	vacant	64220	Fuse Detonator Magazine
	54360		64230	Fuse Detonator Magazine
• •	54361		64240	Fuse Detonator Magazine
	54362		64250	Igloo Storage
	54430		64251	Vacant
			64310	Fuse Detonator Magazine
	54431		64320	Fuse Detonator Magazine
	54440		64330	Fuse Detonator Magazine
	54441		64340	Fuse Detonator Magazine
	54442		64350	Igloo Storage
	54450		64351	Vacant
	54460	♥	64360	Igloo Storage
	54461	Vacant	64361	Vacant
	54480	Elevated Water Tank NP	64420	Fuse Detonator Magazine
=	54500	Administrative	64440	Fuse Detonator Magazine
H-15	54700	Vacant	64450	Fuse Detonator Magazine
ப	561 5 0	Chlorinator	64460	Igloo Storage
	56810	Sewage Treatment Plant	64461	Vacant
and the state of	56860	Sewage Treatment Plant	74013	Water Pump NP
	56900	Sewage Pump	77910	Vacant
	57013	Water Pump NP	77950	Other
	57190	Water Pump NP	77960	Other
	60020	Civilian Personnel	810 20	Other
• .	64040	Sentry Station	81021	Septic Tank Drainage Field
	64050	Sentry Station	81111	Other
	64110	Fuse Detonator Magazine	83010	Igloo Storage
	64120	Fuse Detonator Magazine	83011	Vacant
	64130	Fuse Detonator Magazine	83020	Igloo Storage
	64140	Fuse Detonator Magazine	83021	Vacant
,	64150	Igloo Storage	83110	Igloo Storage
	64151	Other	83111	Vacant
	64210	Fuse Detonator Magazine	83120	Igloo Storage

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Building Number	Description	Building Number	Description	. ·
83121	Vacant	84031	Vacant	-
83210	Igloo Storage	84110	Igloo Storage	
83211	Vacant	84111	Vacant	
83220	Igloo Storage	84120	Igloo Storage	
83221	Vacant	84121	Vacant	
83310	Igloo Storage	84210	Igloo Storage	
83311	Vacant	84211	Vacant	
83320	Igloo Storage	84220	Igloo Storage	
83321	Vacant	84221	Vacant	
83410	Igloo Storage	84230	Igloo Storage	
83411	Vacant	84231	Vacant ·	
83420	Igloo Storage	84310	Igloo Storage	
83421	Vacant	84311	Vacant	•
83430	Igloo Storage	84320	Igloo Storage	
83431	Vacant	84321	Vacant	
83510	Igloo Storage	84410	Igloo Storage	
83511	Vacant	84411	Vacant	
83520	Igloo Storage	84420	Igloo Storage	
83521	Vacant	84421	Vacant	
83530	Igloo Storage	84430	Igloo Storage	
83531	Vacant	84431	Vacant	
83610	Igloo Storage	84440	Igloo Storage	
83611	Vacant	84441	Vacant	
83620	Igloo Storage	84450	Igloo Storage	
83621	Vacant	84451	Vacant	
83630	Igloo Storage	85010	Igloo Storage	
83631	Vacant	85011	Vacant	
84010	Igloo Storage	85020	Igloo Storage	
84011	Vacant	85021	Vacant	
84020	Igloo Storage	85030	Igloo Storage	•
84021	Vacant	85031	Vacant	
84030	Igloo Storage	85040	Igloo Storage	

Building Number	Description	Building Number	Description
85041	Vacant	85330	Igloo Storage
85120	Igloo Storage	85331	Vacant
85121	Vacant	85340	Igloo Storage
85130	Igloo Storage	85341	Vacant
85131	Vacant	85350	Igloo Storage
85140	Igloo Storage	85351	Vacant
85141	Vacant	93132	Water Well with PS
85150	Igloo Storage	93232	Water Well with PS
85151	Vacant	93332	Water Well with PS
85160	Igloo Storage	93432	Water Well with PS
85161	Vacant	93820	Industrial Waste Treatment
85230	Igloo Storage	96621	Vacant
85231	Vacant		7434

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APPENDIX I

ANALYSIS OF EXISTING FACILITIES/ENVIRONMENTAL ASSESSMENT REPORT PINE BLUFF ARSENAL REVISED 1 DECEMBER 1976

A copy of this report can be obtained from:

Department of the Army Headquarters, Pine Bluff Arsenal Pine Bluff, Arkansas 71601

APPENDIX J

US AEHA WASTE TREATABILITY STUDY NO. 24-044-73/76

13 FEBRUARY - 21 MARCH 1974

A copy of this report can be obtained from:

APPENDIX J

US AEHA WASTE TREATABILITY STUDY NO. 24-044-73/76

13 FEBRUARY - 21 MARCH 1974

A copy of this report can be obtained from:

APPENDIX L

US AEHA INSTALLATION RESTORATION PROGRAM REPORT NO. 99-065-75/76

PINE BLUFF ARSENAL

28 - 31 JULY 1975

A copy of this report can be obtained from:

APPENDIX M

PRELIMINARY ENVIRONMENTAL SURVEY PINE BLUFF ARSENAL DECEMBER 1972

A copy of this report can be obtained from:

Department of the Army Chemical Systems Laboratory (DRDAR-CLL) Aberdeen Proving Ground, MD 21010

APPENDIX N PINE BLUFF ARSENAL REGULATION 420-5 SOLID WASTE DISPOSAL

A copy of this report can be obtained from:

Department of the Army Headquarters, Pine Bluff Arsenal Pine Bluff, Arkansas 71601

APPENDIX 0

STANDING OPERATING PROCEDURE NUMBER 71-7 OPERATIONS OF SEWAGE TREATMENT PLANTS PINE BLUFF ARSENAL

A copy of this report can be obtained from:

Department of the Army Headquarters, Pine Bluff Arsenal Pine Bluff, Arkansas 71601

APPENDIX P

US AEHA SOLID WASTE SURVEY NO. 26-001-73/74

PINE BLUFF ARSENAL

4 - 6 JUNE 1973

A copy of this report can be obtained from:

APPENDIX Q

US AEHA WATER QUALITY GEOHYDROLOGIC CONSULTATION NO. 24-004-74

PINE BLUFF ARSENAL

16 - 20 JULY 1973

A copy of this report can be obtained from:

APPENDIX R

EDGEWOOD ARSENAL TECHNICAL REPORT EO-TR-76077

EFFECTS OF ELEMENTAL PHOSPHORUS ON THE BIOTA OF YELLOW LAKE

PINE BLUFF ARSENAL

MARCH 1974 - JANUARY 1975

A copy of this report can be obtained from:

Department of the Army Chemical Systems Laboratory (DRDAR-CLL) Aberdeen Proving Ground, MD 21010

APPENDIX S

EDGEWOOD ARSENAL TECHNICAL REPORT EB-R-76038

RESULTS OF AQUATIC SURVEYS AT PINE BLUFF ARSNEAL

SEPTEMBER 1973 - OCTOBER 1974

A copy of this report can be obtained from:

Department of the Army Chemical Systems Laboratory (DRDAR-CLL) Aberdeen Proving Ground, MD 21010

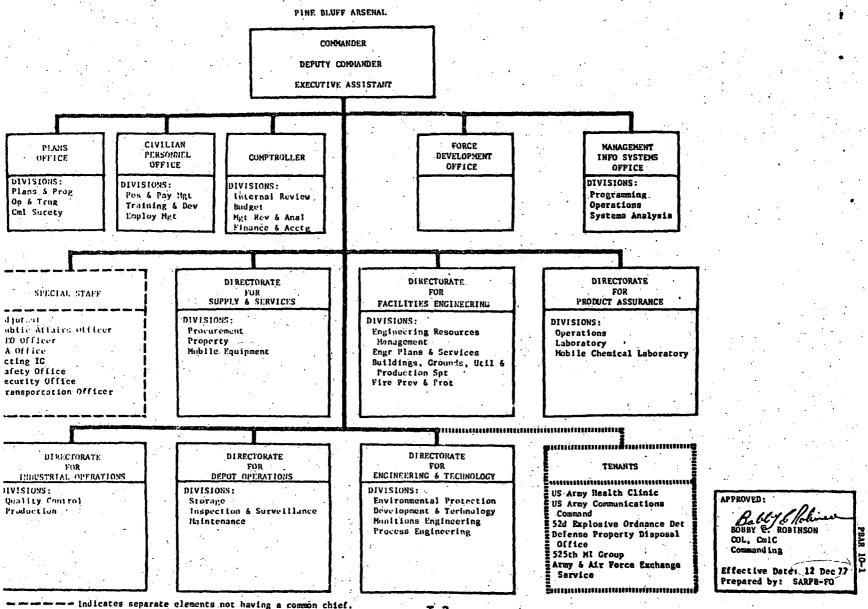
APPENDIX T PINE BLUFF ARSENAL INPUT 23 DECEMBER 1977

CHAPTER 3

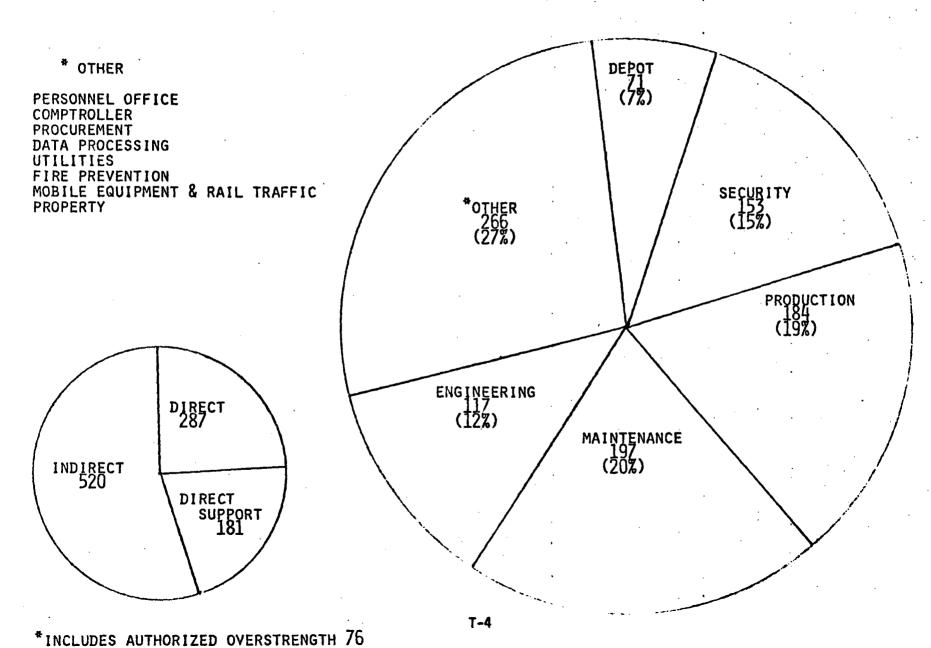
MISSION

3-1. Mission. To operate pilot production, pre-production, and limited production facilities for the manufacture of smoke, riot control, incapacitating, incendiary, and pyrotechnic mixes and/or munitions as assigned; to produce or manufacture chemical, smoke, riot control, incapacitating, incendiary and other pyrotechnic mixes and/or munitions to supplement commercial industrial capacity; to operate limited production facilities in the manufacture of chemical defensive items, to include impregnation of clothing and assembly of protective masks; to support research, development and engineering activities of other US Army Materiel Development and Readiness Command (DARCOM) activities through operation of the facilities cited above, including manufacturing technology, origination and implementation of improvement and modernization projects; to receive, store, perform surveillance, renovate, demilitarize, and ship chemical, conventional, riot control, smoke, and incendiary agents and/or munitions, industrial components and strategic materials; to receive, store and ship supplies and equipment of other governmental agencies; to perform planning in support of mobilization requirements and schedules prepared by Headquarters, US Army Armament Materiel Readiness Command (ARRCOM) in support of the Industrial Readiness Assurance Program for ARRCOM items; to maintain facilities and equipment, active or standby, to assure capability as required for current and future production; to provide testing services and technical advice or assistance to industry in the production of chemical, riot control, smoke and incendiary agents and/or munitions, as required; to provide administrative and logistic support to installation mission activities and attached or tenant activities; to administer a procurement program in support of the installation's mission; to maintain a security program IAW AR 50-6; to operate a mobile chemical laboratory at various DARCOM installations; and to perform installation restoration and chemical demilitarization activities in support of DA Project Manager.

UNITED STATES ARMY ARMAMENT MATERIEL READINESS COMMAND



PBA MANPOWER DISTRIBUTION TDA AUTHORIZED STRENGTH, 988*



INSTALLATION ASSESSMENT OF PINE BLUFF ARSENAL

RECORDS EVALUATION REPORT NO. 113

The following information is recommended for inclusion in the subject report to provide a single-source document showing past, present and future activities addressing the complex problems of environmental pollution and contamination control:

a. Pine Bluff Arsenal Contaminated Areas Project, FY 74-76: Twentynine areas suspected to contain contaminated material were located on Pine Bluff Arsenal (Figure II-10). A project began in FY 74 for collecting and analyzing samples from these areas to determine the extent and concentration of the contamination in each area. The samples were collected according to a statistical sampling plan. The sample analyses consisted of both chemical and biological. The methods for chemical analyses are reported in Edgewood Arsenal Contractor Report, EC-CR-76064, Methods for Analysis of Contaminated Soil, Pine Bluff Arsenal, Pine Bluff, Arkansas, March 1976, by Aubrey B. Gosnell, GO CHEM, Inc., 2075 Elaine Circle, Arkadelphia, Arkansas, Contract No. DAAA15-75-C-0183, Department of the Army, Edgewood Arsenal, ATTN: SAREA-CL-DC (Dr. Emory W. Sarver, Project Officer, 671-3129), Aberdeen Proving Ground, Maryland 21010.

Chemical analyses data is stored at the North East Computer Center, Fort Monmouth, New Jersey, with DDT analyses by isomer stored at the Chemical Systems Laboratory (CSL), Aberdeen Proving Ground, Maryland, in the UNIVAC 1108 system.

All data is scheduled for conversion and entry into the Installation Restoration (IR) data management system at CSL, during FY 78. Information on IR data collection and retrieval for evaluation can be obtained from Department of the Army, Office of the Project Manager for Chemical Demilitarization and Installation Restoration, ATTN: DRCPM-DRR (Mr. Shatto), Aberdeen Proving Ground, MD 21010.

- b. Department of the Army, Army Materiel Command, Armament Command, Installation-Wide Environmental Impact Assessment for Pine Bluff Arsenal, Il September 1975, can be obtained from: Commander, Pine Bluff Arsenal, ATTN: SARPB-ETC, Pine Bluff, AR 71611. The document describes the current discharge of pollutants to the environment which will continue through 1979 when new pollution abatement facilities will be completed. The streams and sites now receiving this discharge will be the most recent addition of pollutants which will need to be considered under any cleanup program.
- c. An Analytical Systems Committee was established by the Project Manager for Chemical Demilitarization and Installation Restoration in September 1975 with the following mission:

- (1) Review state-of-the-art methodology for analyzing known or suspected contaminants at RMA and at other installations requiring subsequent survey; determine knowledge gaps in analytical technology which need to be addressed by research, modification, and verification efforts; and recommend to the Program Manager for Installation Restoration (PMIR) programs, outlining time/cost/manpower requirements, to fill these knowledge gaps.
- (2) Integrate the overall technical efforts of the several agencies involved in analytical technology.
- (3) Monitor approved and funded analytical technology programs to assure that analytical procedures and equipment used for defining the contamination profile (before and after decontamination) are acceptable from the standpoint of economics, speed, precision, accuracy, and reproducibility, and assure that such programs are in compliance with statuatory and regulatory requirements.
- (4) Insure the development and administration of an extensive quality control program which will insure reliable analytical results.

Draft copies of approved methods concerning the analytical requirements for the Installation Restoration Program at Pine Bluff Arsenal can be obtained from this committee at Project Manager for Chemical Demilitarization and Installation Restoration, ATTN: DRCPM-DRR, Aberdeen Proving, MD 21010.

- d. Standing Operating Procedure Number 74-21, Spill Reaction Plan for Oil and Hazardous Substances, 18 Apr 75. A copy of this report can be obtained from: Commander, Pine Bluff Arsenal, ATTN: SARPB-FAE, Pine Bluff, AR 71611.
- e. Standing Operating Procedure Number 71-9, Preparation of Plans and Projects Natural Resources, Land, Forest and Wildlife Management, Roads and Railroads, 30 Oct 74. A copy of this report can be obtained from:

 Commander, Pine Bluff Arsenal, ATTN: SARPB-FAE, Pine Bluff, AR 71611.
- f. Summary of Public Laws Related to Pollution Abatement: The first public law (PL 92-500) relates to traditional water quality parameters such as pH, suspended solids, biochemical oxygen demand and oil and grease with a statement on toxic substances which is the basis for an early study on potential contaminated areas. This public law will be met in 1979 through on-going construction.

The second public law (PL 95-95) deals with air quality which, like the initial public law, will be met in 1979 through ongoing construction.

The third public law, 92-500, 40CFR, part 129, Toxic Pollutant Effluent Standards, applies to our current DDT problem with rules published in the Federal Register on 12 Jan 1977 stating that DDT will cease to be discharged (zero, i.e., 10 parts per trillion) by 12 Jan 1978. Additional rule making

under this act will likely continue and may include up to 165 new chemicals by 1983.

The last two public laws are new and PBA is attempting to understand these public laws as they apply to Pine Bluff Arsenal by requesting funds for study, design, alteration, or construction of new facilities to meet these criteria.

There have been a total of four public laws passed by Congress to date which apply to pollution abatement efforts at Pine Bluff Arsenal and are listed as follows:

- (1) The Federal Water Pollution Control Act of 1970, as amended 1972, PL 92-500 (NPDES Permit)
 - (2) Clean Air Act Amendments 1977 PL 95-95
- (3) The Federal Water Pollution Control Act of 1970, as amended 1972, PL 92-500, 40CFR, Part 129, Toxic Pollutant Effluent Standards (DDT)
 - (4) The Toxic Substances Act PL 94-469
 - (5) Solid Waste Disposal Act PL 94-580
- g. DDT Containment Project: The survey (1a, above) indicated that DDT, heavy metals and Phosphorus were the major problems at PBA.

Since DDT was the major problem, a program was initiated in late 1975 and completed in 1977 to reduce the level of migration of DDT off-post using the existing standards in the literature. Blue gill fish were used as the test organism for aquatic life and the goal of the project was to not exceed the concentration of 0.05 of the 96 hour TLM_{50} . To accomplish this task, White Creek was diverted around the landfill in the south area and Triplett Creek in the north area was diverted upstream away from the major contaminated areas. In the south area, the old landfill was resealed with clay, covered with topsoil and reseeded with grass. In the north area, large areas of ground were covered with crystalline DDT up to five inches thick around the old production buildings and had washed into Triplett Creek and contaminated the creek the full length and into the Arkansas River. In the north area after stream diversion, retention basins were constructed prior to pickup and burial of DDT in three areas to avoid a high discharge of DDT into the Arkansas River during the rainy season which was concurrent with the cleanup effort. The areas were sealed with clay, covered with topsoil and reseeded with grass. No attempt was made to clean up the same ten miles of stream bed which make up both creeks since this would have been very costly and was not required to meet the 96 hour TLM₅₀ for blue gill fish. In brief, once the source had been eliminated, natural silting would have sealed the streams to the extent the test criteria could be met. The above tasks in both the north and south areas

are complete and were accomplished with Arsenal technical staff and labor.

- h. Public Law 92-500, 40CFR, part 129 (DDT Zero Discharge): Pine Bluff's most immediate problem is Public Law 92-500, 40CFR, part 129, which limits discharge to zero by 12 Jan 1978. Due to the complex nature of a problem dealing with such low levels of discharge (10 parts per trillion), that is one drop in 13,000 gallons, two contractors were retained to establish various engineering alternatives and their cost to meet the standard and to identify the level of DDT in the environment around and entering Pine Bluff Arsenal. These low levels were suspected of being in the area since DDT had been used by the private sector for many years. These studies will be completed in early December 1977 with some decision as to a course of action being developed and forwarded to EPA. Preliminary background studies have been accomplished by PBA which indicate that rain water contains 325 parts per trillion (ppt), the Arkansas River both up- and downstream, 189 ppt, and sediment in the river both up- and downstream approaching 1 million parts per trillion. DDT is soluble in water at 3,000 ppt with sediment continually mixing with water on occasion to allow the water to reach this level. The initial PBA task was to deny this contact between water and sediment containing crystalline DDT.
- i. Ecology Program: An overall PBA Ecological Program is being developed under contract with Battelle-Columbus Labs to insure that future discharge from active production sources does not continue to impact on the environment. Program outline may be obtained from Commander, Pine Bluff Arsenal, ATTN: SARPB-ETD, Pine Bluff, AR 71611.
- j. Installation Restoration Program: In early 1976, the Army assigned a program manager to help installations such as Pine Bluff Arsenal, with migration problems (from inactive production sites) at the boundary/off-post interface for both surface and subsurface. Currently, a preliminary investigation of the contaminant situation covering all materials identified in the initial survey is in progress. This initial program will be completed during 1978 with recommendations being available after that time. Information on this program can be obtained from the Project Manager for Chemical Demilitarization and Installation Restoration, Aberdeen Proving Ground, MD 21010.
- k. PBA Supplement 1 to AMCR 11-5 Environmental Enhancement and Pollution Abatement: The document provides a list of Environmental Impact Assessments, Pollution Guidelines for Directors of various operational units and examples of actions requiring coordination with the PBA Environmental Coordinator.

- 1. Contract for Use of PBA Facility to Manufacture DDT by Private Contractor: Efforts should continue to locate contracts thought to be in CE files in either Fort Worth or Little Rock. Records have not been found at PBA.
- m. <u>Interviews</u>: Efforts should be made to interview the following people:
 - (1) COL Lovelady: office phone (501) 378-6213 home phone - - (b) (6) Little Rock, AR Job: Production Foreman in DDT Plant
 - (2) Dr. William Trigg Arkansas Tech, Russellville, AR
 Department of Chemistry
 Job: Haul waste to pits from DDT Plant
 - (3) Mr. Hickerson Altheimer, AR
 Job: Haul waste to pits from DDT Plant
- n. Phosgene was stored in TSY. Also, demil and transfer operations occurred here.
- o. GB, VX were never held in TSY but were stored in igloos in ammunition storage areas.
- p. Mustard shells have been found in area along Arkansas River in area noted 1 in II-14.
- q. Building 53-990 was leased to a paper bag company during the 1950's and 60's.
 - r. Building 50-510 was leased to an ink manufacturer in early 1960's.

APPENDIX U

INSTALLATION RESTORATION ACCOMPLISHMENTS AS OF OCT 79.

APPENDIX U INSTALLATION RESTORATION ACCOMPLISHMENTS

AS OF OCT 79

The records research program documented in this report was the first step in identifying probable areas of contamination at PBA. Since this report identified a number of contaminated sites, programs were initiated to (a) develop a contamination profile in groundwater, surface water, soil and sediment, and (b) to develop and implement corrective measures to prevent actual or potential off-post contaminant migration. A brief discussion of each follows:

- a. <u>Contaminant Profile</u>. Thousands of samples have been collected and analyzed from groundwater, surface water, soils and sediments. The results are being entered into an Installation Restoration data base. Preliminary checks indicated that there is no off-post migration of contaminants in excess of EPA standards, that there are currently high levels of chlorides and sulfates in some on-post groundwater monitoring wells, and that there is nonmigrating contaminated soil present on the installation. All scheduled sampling and analysis activities required to complete the installation contamination profile were completed in September 1979. During FY80, a comprehensive analysis will be made of the types, locations and concentrations of each contaminant. Specific attention will be given to any results indicating that a compound(s) is in excess of EPA standards, and to those with migratory potential, (i.e., present in water or sediment).
- b. <u>Migration Containment</u>. Preliminary surveys indicated that DDT and arsenic were being carried in the sediment of Phillips Creek and White Creek toward the Arkansas River. To correct the problem, the following actions were taken:
- (1) In the southern part of the Arsenal, where DDT had been dumped in an old landfill, a stream (White Creek) was diverted around the landfill, and the landfill itself was covered with clay, compacted, surfaced, sloped, topped with fertile soil, grassed over, fenced off and posted with protective signs.
- (2) In the northern part of the Arsenal, where the DDT had been manufactured, more extensive preparatory measures were necessary. Three sediment retention basins were constructed, each downslope from a major DDT deposit. A small tributary of Triplett Creek, upstream of the deposits, was diverted some 800 feet to a neighboring tributary to reduce the scoperequirement for the third basin. Then the crystalline DDT material was scooped up and placed in the hydraulically-sealed foundations (basements)

of previously razed buildings located nearby. Finally, these DDT-filled basements were sealed off with clay, and otherwise treated like the land-fill in the south. While the basements were large enough to accept the crystalline and concentrated DDT material, a large volume of contaminated soil was also loosened by the scooping and grading. This contaminated dirt was gathered onto the property adjacent to the old manufacturing site and there covered with clay, in the manner of the other sites.

(3) White and Phillips Creeks are monitored monthly. The actions described above have been effective in preventing any further off-post migration. Although greatly reduced, some contaminated sediment is still moving slowly down Phillips Creek. To stop all remaining migration, 3 additional basins have been designed and an MCA request for funds submitted to permit construction in FY82.

A complete final report documenting the results of the contamination survey and the corrective measures taken to eliminate DDT and arsenic migration problems will be prepared by April 1980.